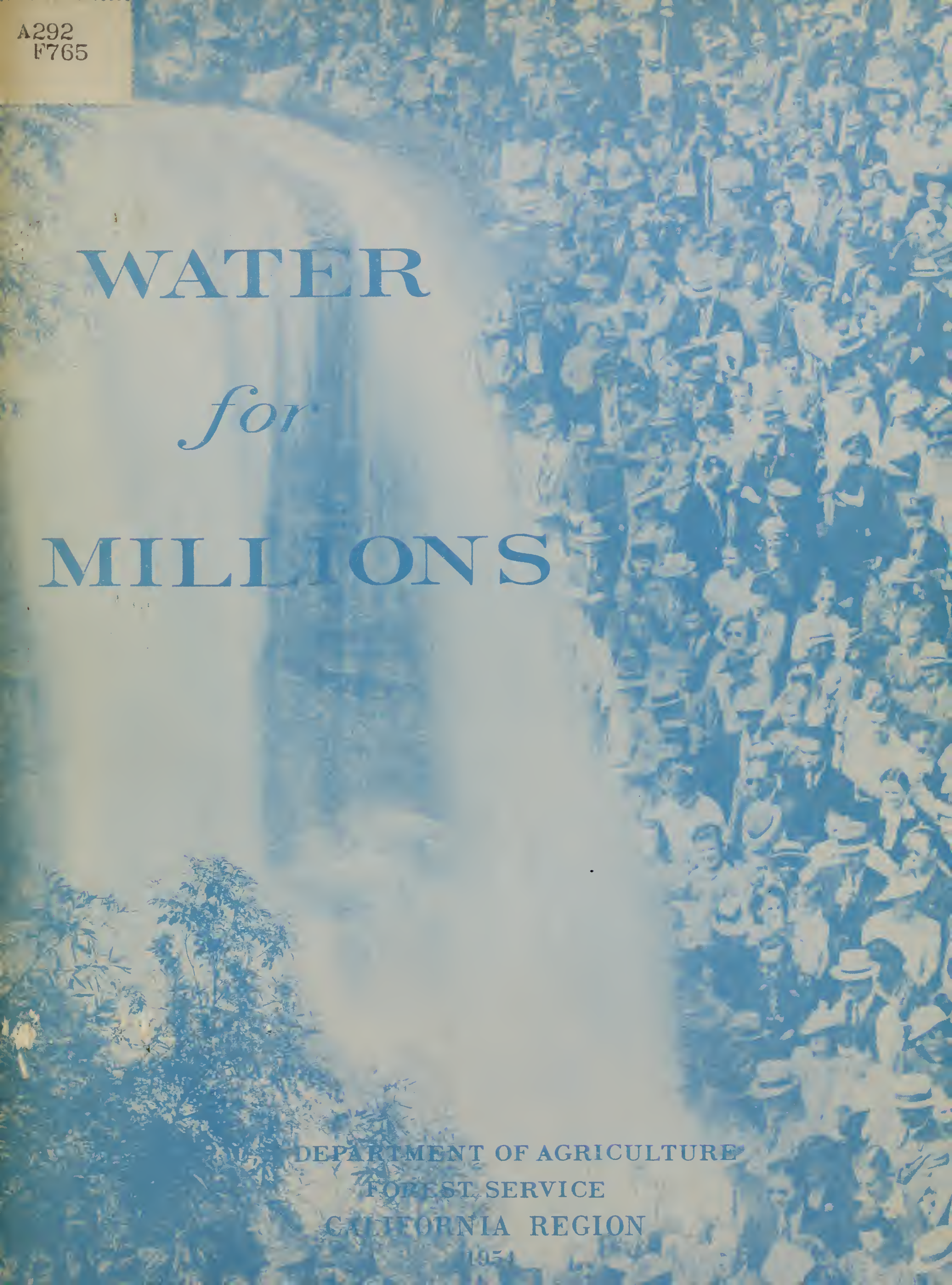

WATER *for* MILLIONS

DEPARTMENT OF AGRICULTURE
FOREST SERVICE
CALIFORNIA REGION
1954

WATER FOR MILLIONS

By

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San Francisco, California 1954

"It is the solemn duty of our generation to plan wisely for the best use for all purposes of every drop of water. Upon such planning will depend the happiness and welfare of millions of people, of this generation and of future generations. Uncontrolled, water is a force of destruction. Controlled and put to use, it is mankind's greatest benefactor."

The Honorable Earl Warren, Chief Justice
of the United States Supreme Court, and
former Governor of California.

ACKNOWLEDGMENT

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Wallace I. Hutchinson

Cooperators

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Soil Conservation Service, U. S. Department of Agriculture
Title Insurance & Trust Company, Los Angeles
Union Pacific Railroad
Union Title Insurance & Trust Company, San Diego
Ventura County, County Surveyor's Office

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THE MOTHER OF WATERS

To people in different parts of our country WATER means many things. To Southern Californians it means thriving communities, great industries, fertile fields, orchards, and vineyards, sport and recreation, and happy living. As the prophets of old looked to the hills from whence came their help, so today must the people of the Southland look to the mountains for the life-giving water which spells their destiny.

THE SETTING OF THE STORY

This is a story of WATER and PEOPLE.

Along the southern coast of California where the Pacific shoreline swerves southeastward from Point Conception lies one of the richest "empires" in America, popularly known as Southern California. This great coastal plain, walled off from the Central Valley and Mojave and Colorado Deserts by mountain ranges, is some 350 miles in length and from 35 to 100 miles in width. Its total area is more than 20,000 square miles, or roughly one-eighth of the land area of California.

Southern California, in the sense used here, includes in general the mountains, cultivated lands, and urban areas in Santa Barbara, Ventura, Los Angeles, Orange, San Bernardino, Riverside, and San Diego Counties. The Imperial Valley in Imperial County and the Coachella Valley in Riverside County, which belong geographically to the Colorado River Basin, are also included because of their close tie with the water and agriculture problems of the coastal region.

In this Southland are some 5,650,000 people, or over one-half of the total population of the State. More than 4 million of these people live in Los Angeles County; 2 million in the City of Los Angeles. Throughout this highly urbanized region are some 350 cities, towns, and rural settlements interlaced by a network of highways, power lines, and water conduits. The people are a heterogeneous mixture of racial stocks, occupations, and religions -- both native born and people from every state in the Union, and many foreign countries.

Except for a salubrious climate with a maximum of sunshine, Nature has been frugal with her resources in Southern California. Rainfall is limited, and confined to a few winter months. Soils of the valleys are of recent origin, geologically speaking, and largely composed of materials washed down from the mountains, forming great alluvial fans. Rivers are short in length, few in number, and irregular in surface flow. Forests are confined to open stands of conifers at high elevations flanked by lower mountain slopes covered with dense thickets of chaparral. Strong desert winds, called "Santanas", often bring heat and clouds of dust.

Despite these apparent handicaps, the Southland has blossomed into one of America's most noted empires -- leading in irrigation agriculture, rapidly growing in population, industry, and wealth, and known far and wide as "a good land in which to live".

What transformed this semiarid region into an immense garden of citrus fruits, dates, nuts, vegetable and field crops? What made possible comfortable homes and jobs for the 4 million people who have migrated to this empire in the past 30 years?

WATER is the answer. Water for the thousand and one daily needs of the people. Water for thirsty fields and citrus groves. Water for factories, mills, and refineries. Water -- the key to the growth and prosperity of Southern California.

PART I. UNQUENCHABLE THIRST

THE VANGUARD OF WATER SEEKERS

For two hundred years after Juan Rodriguez Cabrillo, a noted Spanish explorer, first discovered Southern California, the population growth was stagnant. In 1769 came the Franciscan Fathers who established a series of Missions on the coastal plain. Under the vast land-tenure system of the Padres, thousands of untutored native Indians cultivated the Mission fields and orchards and tended their herds of livestock. This control over the Southland lasted for nearly 60 years.

Next came the extravagant years of the Dons. The vast estates controlled by the Missions were broken up into a checkerboard of ranchos, some rivaling Eastern States in size, over which roamed great herds of sheep and cattle. For the Dons these were days of fiestas, fine horses, and easy living; for the Indians they were days of virtual slavery. A series of dry years in the 1860's practically wiped out the livestock industry in the Southland. Many of the great ranchos were subdivided, and the whole region entered into a new era of agriculture.

In the records of early Mission days there is repeated mention of the scarcity of water in this semiarid region. The first attempt by white man to develop a system of irrigation in the Southland was a primitive stone dam and tile aqueduct built by the Padres about 1810 to supply water to the crop lands of the San Diego Mission. The original water system of El Pueblo de Nuestra Senora la Reina de Los Angeles, founded in 1781, was a brush toma, or intake made by building a brush and earth wing-dam into the Los Angeles River which diverted water into the Zanja Madre, or mother ditch, thence to irrigate crops and orchards, and later to supply the pueblo with water through pipes of hollowed logs. Santa Barbara's water supply was first obtained from Mission Creek; later from artesian wells, and a tunnel driven into the mountains to tap underground sources of water. San Diego, in early days, pumped its water by windmills from the sands of the San Diego River.

The rapid development of citrus culture and specialized farm crops toward the end of the nineteenth century soon resulted in the overuse for irrigation of the surface water of streams flowing onto the coastal plain. This deficiency was offset temporarily by drilling wells to tap underground sources of water. By 1900 there were more than 10,000 wells in Southern California, of which some 1,500 were artesian wells. Windmills dotted the land. Within two decades the artesian flow had practically disappeared and wells had to be driven deeper and deeper and equipped with powerful electric pumps to raise the water. Thus the farmers of the Southland learned the hard lesson that unregulated streamflow and overuse of underground water spells disaster to the successful irrigation of crop lands.

TOO LITTLE AND TOO MUCH

The traveler first seeing Southern California's luxuriant vegetation and extensive citrus groves often receives the mistaken impression that this is a land of abundant rainfall. Most of the precipitation, however, occurs during the winter months of November to March, inclusive; it seldom rains from May to October. In the mountains the rainfall averages 30 to 40 inches annually; on the coastal plains 10 to 15 inches; and in the Imperial and Coachella Valleys 2 to 5 inches. Precipitation varies widely as one travels inland from the coast. Sometimes there will be long winter periods without rain. Then in a single month, occasionally in a single storm, the Southland will receive one-half or more of its total annual rainfall.

Southern California's weather is a succession of dry and wet cycles -- even until today there has been the alternating fear of either drought or flood. A study of 559 years (1385-1944) of growth-rings of trees in the mountains of the Southland made by scientists of the University of Arizona, indicates that the average length of dry periods was about 15 years, with individual dry periods ranging from 6 to 40 years or more. The average length of wet periods was found to be about 12 years, with individual wet periods of from 4 to more than 20 years. Like proof of dry and wet cycles is offered by weather records obtained from Mission reports, the diaries of old settlers, and official Weather Bureau observations.

(1) SAN DIEGO IN 1873

The earliest settlement on the Pacific Coast was made at Old Town, San Diego in 1769 by Don Gaspar de Portola, General-in-charge of an expedition from Mexico. San Diego was incorporated in 1850.

(2) MODERN SAN DIEGO

The second largest city in Southern California (Pop. 434,924 - 1953) with a splendid harbor, great Naval Base and airfields, and substantial business and residential districts.

(3) LOS ANGELES IN 1853

On August 2, 1769, feast day of the Blessed Virgin, General Portola reached the site of the present city and named it El Pueblo de Nuestra Senora la Reina de Los Angeles. The pueblo was founded in 1781.

(4) METROPOLIS OF THE SOUTHLAND

The once sleepy Spanish pueblo is today the third largest city in the United States, with an area of 450 square miles and a population of 2,104,663 persons (1953).

Drought probably more than floods has shaped the destiny of SouthernCalifornia. Early Mission crop reports indicate a period of rainfall shortage from 1781 to 1810. In 1795 Fr. Sanchez of San Gabriel Mission tells of sending the neophytes into the mountains to search for food because of crop failure. Extreme drought conditions prevailed from 1821 to 1832, except for one large flood in 1825, and caused Fr. Fernando Martin of Mission San Diego to write Governor Echeandia in January 1829: "In this year of drought, when there is no pasture for the sheep, where shall they be placed?" The scant rainfall in 1862-1864 resulted in death for many thousands of cattle from lack of forage and water. One of the longest and most acute droughts in the history of the Southland began in 1893 and lasted for almost ten years. This was followed by another period of intermittent dry years from 1922 to 1931. In the past ten years (1945-1954) a dry cycle, broken only by the wet year of 1952, has held the Southland in its grip. The calendar year of 1953 was the driest year in Weather Bureau history dating back to 1877.

Rain may be "sweet music to the California ear", but not when it comes in such torrents as to cause disaster. Floods are the bane of the Southland, and are of record as far back as 1770 when Fr. Juan Crispi wrote in his diary of great floods that caused the Los Angeles River to leave its bed and later made necessary the moving of the San Gabriel Mission. Since that date until the present there have been some 25 major floods on the coastal plain from Santa Barbara to San Diego. Following are a few of the most destructive floods:

Flood of 1825: One of the greatest of early floods. Changed the course of the Los Angeles and Santa Ana Rivers.

Flood of 1861-62: Called the "great flood". Caused by very heavy and continuous rains throughout the Southland during December and January. Flooded towns and destroyed homes, vineyards, and orchards over a large area.

Flood of 1884: A major flood that did severe damage from Ventura to San Diego. All bridges but one on the Los Angeles River were washed out; San Fernando Valley was flooded, and the Santa Ana River cut a new channel to the sea.

Flood of 1916: Caused by heavy rains over all Southern California. Lower Otay Dam (40, 000 acre-feet capacity; cost $2, 500, 000) of the San Diego water system, destroyed. Flood damage to agriculture lands, water supply, railroads, and highways, principally in San Diego County, $10, 000, 000. Lives lost -- 28, of which 22 were in San Diego County.

Flood of 1934: Local but destructive flood in La Canada Valley near Glendale. Caused by heavy rain on 5, 000 acres of steep mountain slopes denuded of chaparral cover by a man-caused fire two months previous. Lives lost -- 30. Property damage -- $5, 000, 000.

Flood of 1938: Caused by a series of heavy rainstorms throughout the Southland, centered along the coastal slopes of the San Gabriel and San Bernardino Mountains. Total damaged area -- 427, 000 acres. Direct property damage to agriculture, residences, railroads, bridges, and public utilities -- $51, 000, 000; estimated indirect damage -- $27, 000, 000.

Flood of 1952: Two storms in January swept the Southland with heavy winds and rains, and snowfall in the mountains. Flood waters, erosion, and land slides stalled trains, damaged houses and merchandise in stores, washed out highways and bridges, toppled trees and power lines, and drove hundreds of people from their homes. Eleven persons lost their lives as a direct result of the storms, and property damage totaled more than $3, 700, 000.

The succession of droughts and floods that plagued the Southland early awoke the people to the necessity of controling the flow of streams at their source and providing for the storage of flood waters for use in dry years. In the decade following 1880 many dams were built and new lakes born in the mountains, from which long flumes of wood or concrete carried water to towns, orchards, and agricultural lands. Water companies and irrigation districts sprang up in rapid succession to meet the needs of new communities and expanding irrigated acreage.

(5) REMAINS OF MISSION DAM

Earliest known irrigation project in California, built about 1810-16, was Mission Dam on Mission Gorge of the San Diego River and a 5 mile conduit that supplied water to lands of Mission San Diego.

(6) WOODEN WATER WHEEL

Part of Los Angeles' original water system was a large wooden water wheel which raised water from the Zanja Madre, or mother ditch, to a flume running to a brick building (reservoir) in the Plaza.

(7) DEPLETED RESERVOIR

Morena Reservoir, San Diego County, after more than 7 years of subnormal rainfall. The water level is 86 feet below the crest of the spillway; water storage is 40 percent of the reservoir's capacity.

(8) DESERTED RANCH

Lack of adequate water supplies for domestic and agricultural use has forced many a rancher to abandon his home and lands.

PROTECTING THE SOURCE

The principal local source of water for the coastal plain of Southern California is the steep-sloping mountains which parallel the coastline in a series of broken ranges from north of Santa Barbara to east of San Diego. The soils of the mountains absorb water readily, but are generally shallow and are subject to erosion if laid bare by fire or other causes. The plant cover on the mountain slopes up to about 5,000 feet elevation consists principally of "chaparral" (a mixture of brushy shrubs and dwarf trees), with scattered stands of trees (oaks, pinyon pine, and juniper) on the desert side, and alders, sycamores, maples, and oaks along the streams. From 5,000 feet to timber line are limited areas of open forests of pine, fir, and spruce. Chaparral, however, is the predominating plant cover of the mountains.

Long before the people of the Southland began to explore the streams and lakes in the mountains for additional water supplies, squatters and homesteaders had found and settled on the fertile canyon bottoms and in the hidden valleys of the coast ranges. Stockmen grazed their cattle on the mountain meadows; miners staked out claims along the creeks; and lumbermen cut the timber in the high country forests. Great forest fires, started by lightning or man, burned throughout the dry summer months. Most of the mountain area was "public domain" belonging to the Federal Government, and no one showed much concern over the illegal use or destruction of the natural resources.

In the 1880's a small group of conservation-minded men and women started a movement for the preservation of the mountain forests and watersheds of Southern California. Their leader was Abbott Kinney, a botanist of note and founder of the beach town of Venice. He was also an officer of the American Forestry Association and the chairman of the first California State Board of Forestry established in 1885. In its first report to the Governor the Board of Forestry stated: "The destruction of the forests in the southern counties means the destruction of the streams, and that means the destruction of the country." Soon prominent citizens, boards of supervisors, chambers of commerce, irrigation districts, and many organizations joined in the battle which became a part of a Nation-wide campaign for forest preservation.

FLOODS

(9) SAN DIEGO RIVER - 1916

Floods in 1916 were general throughout the Southland, but did greatest damage in San Diego County. Lower Otay Dam was destroyed, 20 lives lost, and damage totaled more than $10,000,000.

(10) LOS ANGELES RIVER - 1938

In March 1938 11 inches of rain fell in 5 days, flooding 427,000 acres of land and causing property damage of $80,000,000. Eighty-one persons lost their lives as a result of the floods.

FLOOD DAMAGE

(1 1) FLOOD-SWEPT ORANGE GROVE

A layer of sand and debris feet deep deposited in an orange grove by flood waters of the Santa Ana River.

(1 2) ONCE A HOME

A house undermined and wrecked by swirling flood waters of Verdugo Creek that swept through a residential district near Glendale.

In 1891 the President was given power by Congress to establish "forest reserves" from the public domain. A year later a proclamation to create a forest reserve in the San Gabriel Mountains was sent by Commissioner Thos. H. Carter of the General Land Office to Secretary of the Interior John W. Noble with this notation: "The future prosperity of southern California depends upon protecting the water supply of the numerous streams which have their source in the mountains embraced in the reservation..." The proclamation was later submitted to President Benjamin Harrison, who on December 20, 1892 created the "San Gabriel Timberland Reserve" -- the first of such reserves in California.

From 1893 to 1898 additional "forest reserves" were established in the Southland by Presidents Harrison, Cleveland, and Theodore Roosevelt. At first these reserves were under the administration of the General Land Office of the Interior Department, but in 1905, at President Roosevelt's urgent request, Congress transferred them to the Department of Agriculture where they were placed under the newly created Forest Service, headed by the country's first Chief Forester, Gifford Pinchot. In 1907 the forbidding name "forest reserves" was changed to "national forests" to indicate that the resources of these areas are not locked up, but are for the use of all the people.

Today, there are four national forests in Southern California -- Angeles, Cleveland, Los Padres, and San Bernardino -- which include the principal mountain ranges of the Southland and cover an area of more than 3,400,000 acres of Federal land. These forests were created to protect the mountain watersheds of streams which supply water to cities, industries, and crop lands of the coastal plain. Other natural resources of the forests are timber, forage for livestock, and wildlife. They are also popular recreation grounds, visited annually by several million people in search of outdoor life and enjoyment.

THE ENDLESS QUEST

In the years from 1880 to 1900 the Southland experienced a series of "flash booms". Settlers and land seekers poured into

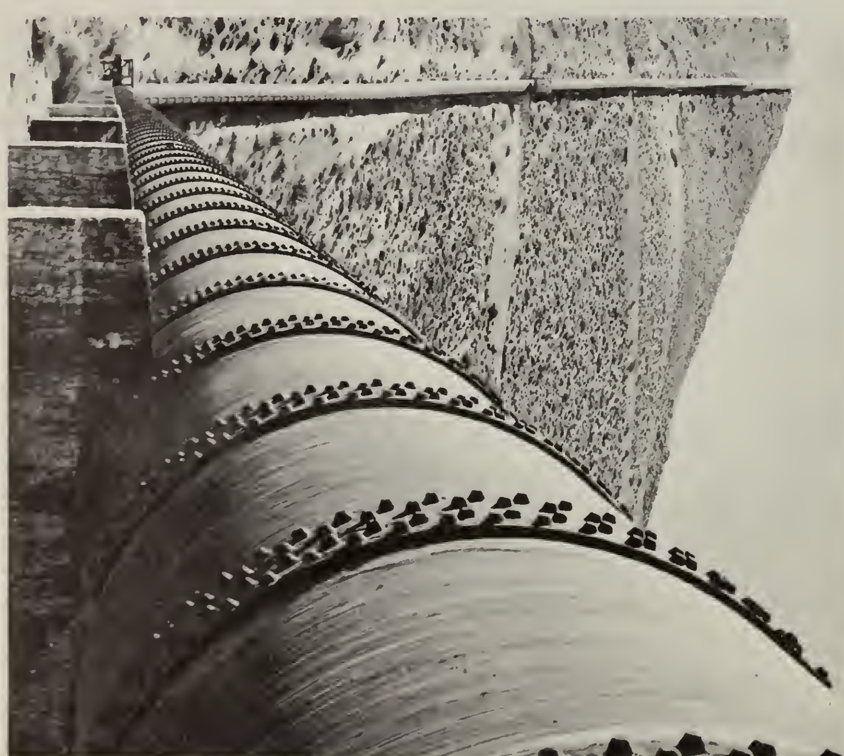
the country; newly completed railroads ran special excursions from the East and Middle West; oil was discovered, and the population grew from 60,000 to more than 300,000 people. With the turn of the century came new hordes of tourists. Subdivisions and town sites sprang up overnight like mushrooms; new communities were developed, and industry boomed. In ten years the population had doubled; by 1920 it had soared to 1,347,000 people. Then came the development of transcontinental highways and the great automobile migration which brought 1 1/2 million new people to Southern California in the decade from 1920-1930. Fabulous oil discoveries, the spectacular growth of the motion picture industry, and the year-long opportunities for outdoor life and recreation, all widely advertised by promotion organizations, were the magnets that drew people from all parts of the world. Since that time the progress of the Southland has been on a steady and sound foundation, ranking high among the fastest growing regions of the United States.

Early in the boom years when Southern California was gripped by drought, officials concerned with water problems suddenly came to realize that the supply available from mountain streams and pumping wells was totally inadequate to meet the needs of the growing population. To forestall this crisis every possible source of water in the nearby national forests was explored, additional wells were sunk on the coastal plain, new dams and conduits were rushed to completion, and even a professional rain maker was employed to aid Nature in pro ducing precipitation.

Los Angeles was especially hard hit. The normal runoff of the Los Angeles River and water from underground sources had failed to keep pace with the daily needs of the increasing population. Other local sources of water were found to be impracticable. In the meantime engineers had been investigating the possibilities of bringing water to the city from the Owens Valley, 250 miles to the north and several thousand feet higher in elevation. Such a plan was accepted by the Board of Water Commissioners and made known to the people of Los Angeles in 1905. Two years later a bond issue of $23,000,000 was voted to secure this new water supply.

(13) LAKE CROWLEY

In Long Valley near the head of the Owens River, flanked by the snow-capped Sierra Nevada in the Inyo National Forest, is Lake Crowley, the largest of seven reservoirs in the aqueduct system.



(14) JAWBONE SIPHON

South of the Haiwee Reservoir, aqueduct water is carried along or through the steep slopes of the south Sierra and across the Mojave Desert by a series of conduits, tunnels, and giant siphons.

(15) SAN FERNANDO RESERVOIR

Completing its 300 mile journey from the snowbanks of the Sierra, aqueduct water cascades into the San Fernando Reservoir to serve homes, farm lands, and industries in the Los Angeles area.

The construction of the Los Angeles-Owens River Aqueduct through rugged mountains and over sun-baked deserts was one of the major engineering feats of its time. The aqueduct proper consists of seven reservoirs and 215 miles of conduits. From the intake on the Owens River, north of Independence, an open canal carries the water 60 miles to the Haiwee reservoir. From this storage basin it flows 120 miles through tunnels, giant siphons and conduits along the southern Sierra Nevada and across the Mojave Desert to Fairmount reservoir. Here the five-mile Elizabeth tunnel pierces the coastal mountains and provides a water drop of 1, 470 feet for the generation of electricity at the San Francisquito power plants. Another series of tunnels and siphons then carries the water to the final reservoir in San Fernando Valley.

On November 5, 1913, at a great public gathering, the first aqueduct water from the Sierra Nevada splashed into the San Fernando reservoir.

The new aqueduct supply was hailed as the solution of the water problem of Los Angeles for many years to come. But ten years later the city was again seeking new sources of water. The light snowfall in the Sierra Nevada in these years and the use of water on Owens Valley lands so reduced the flow of the Owens River that it was necessary to drill many deep wells in the valley to furnish needed water to the growing city. To assure a sufficient supply of water for the aqueduct, practically all remaining private holdings with their water rights in the Owens Valley, totaling nearly 300, 000 acres of land in Inyo and Mono Counties, were purchased by the city.

By 1930 the population had increased to 1 1/4 million, and the citizens, realizing that more water was needed for future growth, voted a bond issue of $38, 800, 000 to expand water facilities and obtain a larger and more dependable supply of water for the Los Angeles Aqueduct. It was found that this could be done by extending the Owens River system into the Mono Basin watershed, 338 miles north of the city. Work on this project was started in 1934 and completed in 1940 at a cost of $22, 800, 000.

To bring Mono Basin water to the aqueduct an 11-mile tunnel was bored through the Mono Craters Divide and two dams were constructed at Grant Lake and in Long Valley. The latter formed Lake Crowley, 10 miles long and five miles wide, with a storage capacity of 183,000 acre-feet.[1] Three power plants utilize the 2,375-foot water-drop from Lake Crowley to the head of the Owens River gorge, and a 250-mile transmission line delivers the electricity to Los Angeles.

The total cost of the Los Angeles-Owens Valley Aqueduct system, including the Mono Basin extension, cost of land, and water rights, approximates $150,000,000.

Other parts of Southern California also faced serious water problems both during and after the boom years at the end of the nineteenth century.

<u>Santa Barbara</u> in 1889, with a population of 5,000, was forced to restrict domestic water consumption and use salt water for street cleaning. Five years later the city again faced a severe water shortage. The sustained drought from 1898 to 1900 necessitated rigid curtailment of all forms of water use by the 6,500 people in the community. These setbacks to the growth and development of the city resulted in an intensive search for new sources of water.

A survey of water resources of the region showed that the Santa Ynez River, on the north side of the mountains back of the city, offered the best storage possibilities. Dams could be built along the river and the impounded water brought to the coastal plain by tunnels bored through the mountains.

The Mission tunnel, 3.7 miles in length, was originally designed to intercept underground flow and was later used to convey water through the mountains. It was completed in 1912. Gibraltar Dam, 600 feet long and 150 high with a capacity of 14,500 acre-feet, was built on the Santa Ynez River in 1920 and connected to the Mission tunnel. In the winter of 1921-22 heavy rainfall filled the reservoir to capacity. Santa Barbara by that time had grown to 20,000 people.

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(1) Acre-foot: The quantity of water (43,560 cubic feet) that would cover one acre to a depth of one foot.

During the drought years of 1929-31 the Gibraltar reservoir slowly went dry. Fires had destroyed the chaparral cover on large areas of the Santa Ynez watershed within Los Padres National Forest, and the resultant erosion and siltation had seriously decreased the capacity of the reservoir. This led the Federal Government to close the entire area to public use as a fire-prevention measure to prevent further damage to the watershed. In order to hold back the silt being washed into the Gibraltar reservoir from Mono and Caliente Creeks, two dams, with a total capacity of 900 acre-feet, were built by the Forest Service in cooperation with the City of Santa Barbara using Civilian Conservation Corps labor. These gave only temporary relief, and were filled with silt by heavy storms within two years after construction. In the late 1920's the Juncal Dam was built on the Santa Ynez River above Gibraltar, to furnish water to the Montecito County Water District through a two-mile tunnel running through the mountains. Santa Barbara secured 300 acre-feet of additional water from this source in return for deeding the dam site and water rights to Montecito.

In 1946-47 the population of Santa Barbara had increased to 42,000 while the water supply steadily decreased for lack of rainfall. Siltation had now reduced the capacity of Gibraltar reservoir to almost one-half, and it was necessary to raise the dam 13 feet to restore the original capacity. At the close of 1947 there was only a four months supply of water left in the reservoir, and the city's emergency wells had to be put into service. In January 1948 the City Council passed a water-rationing ordinance restricting domestic water use, placing commercial water use under special permit, and prohibiting the watering of lawns, crops, and fruit trees. With additional supplies from new wells, water rationing was officially ended in August, although caution in the use of water was urged.

In 1941, to help solve the water problem, the County Board of Supervisors contracted with the Bureau of Reclamation to prepare a long-range water program on a county-wide basis. Four years later the Santa Barbara County Water Agency was established by the State Legislature to negotiate with the government and local water districts. After considering a number of proposed plans submitted by the Bureau of Reclamation, the

Cachuma Project on the Santa Ynez River below Gibraltar Dam was selected and approved in 1948 by Federal, State, and County agencies.

The Cachuma Project, now nearing completion, comprises the following engineering features: 1. Cachuma Dam and reservoir -- earth and rock-fill dam 3,250 feet long and 206 feet high; reservoir 6 miles long, capacity 210,000 acre-feet. 2. Tecolote tunnel through the Santa Ynez Mountains, 6.4 miles long, diameter 7 feet. 3. South Coast conduit, length 26 miles, pipe diameter 48 to 36 inches; several small regulating reservoirs.

This project, financed by Federal funds and built under the supervision of the Bureau of Reclamation at a cost of $40,000,000, will furnish water to the City of Santa Barbara and the water districts of Goleta, Montecito, Summerland, and Carpentaria, comprising some 27,000 acres of residential and irrigable lands. The cost of the project will be repaid through the sale of water.

Throughout 1949-51 subnormal rainfall and dwindling water supplies plagued the Santa Barbara region. By good fortune, the boring of the Tecolote tunnel through the mountains unearthed a water supply of 3,000 to 4,000 gallons per minute. Santa Barbara and Montecito, by the expenditure of $110,000 were able to secure and use this temporary supplemental supply to meet their increasing needs.

Ventura County, like its neighbors Los Angeles and Santa Barbara Counties, has long been confronted by the problem of securing additional water supplies to meet its needs. Rugged mountains cover the northern portion of the county, with population and agricultural development concentrated in the rolling foothills, valleys, and plains of the southern part. Three streams -- the Ventura and Santa Clara Rivers, with their main watersheds in the nearby Los Padres and Angeles National Forests, and Calleguas Creek drain into the coastal area. Precipitation varies from 32 inches in the mountains to 12 inches on the plains. The population of the county in 1950 was 114,647 -- an increase of 65 percent in the previous ten years.

The development of Ventura County began in 1782 when Fr. Junipero Serra established the Mission San Buenaventura in what is now the City of Ventura. In the early 19th century the land was divided into large ranchos where many cattle, sheep, and horses were raised. Agriculture had its beginning in the 1880's with the planting of citrus and walnuts in protected valleys and along river bottoms. Beans, now extensively cultivated on the Oxnard Plain, were introduced just prior to the turn of the century. By 1950 there were more than 2,000 farms in the county with 220,000 acres of croplands, of which 107,000 acres were irrigated land. The area within the county susceptible to intense water-using development is estimated at 235,000 acres, but because of lack of water there has been little increase in irrigated acreage during the past two decades.

Water for domestic use and irrigation was first obtained from the surface runoff of streams. This source, however, proved very erratic and diminished rapidly after storms so that it was necessary to seek additional supplies from underground water basins. Today, there are more than 1,350 heavy-draft wells pumping water for irrigation plus 150 wells supplying water for urban and suburban use.

Increased demands for water and protracted droughts have in recent years focused public attention on the vital need for additional water supplies to maintain existing developments and safeguard the future growth of the county. This has led to intensive studies of the water problem by local, State, and Federal water and resource agencies.

Ventura County's water problems stem from: 1. Lack of dams and reservoirs to conserve water, now wasted into the ocean during wet periods, for beneficial use in drought periods. 2. Perennial lowering of water levels in underground basins, due to excessive pumping and drought. 3. Intrusion of sea water into the coastal area basins. 4. Insufficient surface flow of water in local streams to adequately recharge depleted underground basins.

With the exception of Matilija Dam and reservoir (capacity 7,000 acre-feet) on Matilija Creek, a branch of the Ventura

River, and a few minor surface storage developments, practically the entire water supply of Ventura County is obtained from underground basins, of which there are 17 in the county. Water service in the county is furnished by 112 different water districts and companies, and public and private utilities.

Severe droughts have seriously effected water reserves throughout the county. In the past 60 years there have been three drought periods of 10, 14, and 7 years duration. As a result the water level of some wells on the coastal plain has fallen 80 feet or more, allowing the intrusion of salt water from the ocean, while in other parts of the county wells have gone entirely dry.

One of the first water problems to be solved in Ventura County is the regulation of the erratic local water supply, and the development of facilities for the distribution of water thus conserved to areas of need. The final solution of the county's water problem will require the importation of water supplies from outside sources. In either case the cost will run into millions of dollars.

An initial step in the conservation of waste water was taken in April 1954 when a contract was awarded for the construction of the Santa Felicia Dam on Piru Creek at an estimated cost of $3 1/2 million. The dam will have a height of 270 feet, and the reservoir behind it will have a capacity of 100,000 acre-feet. A diversion line system will deliver the water to the Oxnard Plain and the cities of Oxnard and Port Hueneme. This water development on the Santa Clara River by the United Water Conservation District approximates an expenditure of $10 million.

<u>San Diego</u> and the surrounding urban country has been in quest of water for two centuries. With an average annual rainfall of only 10 inches, the mountain streams of the region provide a limited and extremely variable water supply. Storage reservoirs must, therefore, be depended upon to conserve the flow of wet years to meet the needs of dry years. San Diego was one of the first cities in the Southland to recognize this problem and to take steps to meet it in a realistic manner.

During the boom of the 1880's,when the railroad first reached San Diego, the population jumped from 6,000 to 35,000 and water demands far outstripped the supply available from local streams and pumping wells. A huge scheme, ridiculed by many townsmen, was started to build a diversion dam at the headwaters of the San Diego River and bring water to the city by a 31-mile flume. The project was completed in 1889,barely in time before a severe drought occurred.

In the past 100 years the San Diego region has experienced more than 50 years of below normal rainfall. Three of these dry cycles lasted for periods of 21, 13, and 12 years. One of the driest periods of record was the "great drought" of 1895-06. Through 1903-04 the average seasonal rainfall was less than 7 1/2 inches. During this time many mountain streams ceased to flow, and there was scarcely enough water for human consumption.

Since the construction of the first dam and flume more than 65 years ago, San Diego has expanded its water system to seven major reservoirs and a number of small distribution reservoirs capable of storing in excess of 430,000 acre-feet of water. But today, at the end of another cycle of subnormal rainfall and runoff from the mountain streams, these reservoirs hold less than one-fourth of their capacity.

HARNESSING THE MIGHTY COLORADO

The Colorado River now enters the Southern California water picture.

The Colorado, one of the major rivers of the United States and the largest river in the Southwest, rises in the western slopes of the Rocky Mountains and drains parts of seven states in its 1,700 mile journey to the Gulf of California. In its upper reaches the river travels through great gorges, including the Grand Canyon of the Colorado; in its lower 200 miles it flows through flat mesas and valleys. South of the Mexican border lies the great Colorado River Delta, through which the silt-ladened waters are carried by innumerable shifting channels to the ocean.

Aeons ago the Imperial and Coachella Valleys were an arm of the Gulf of California. The Colorado River, in building up the enormous silt delta at its mouth, cut off this arm from the sea, and in time it became a great dry basin below sea level, called the Salton Sink. As ages passed the erratic Colorado left its natural channel and poured its floods into this depression until the accumulation of silt caused the stream to again turn back southward to the gulf. These repeated deposits of silt on the one-time ocean floor formed rich land that could be irrigated by gravity from the Colorado River.

Water was first appropriated from the lower Colorado River in 1877 for the irrigation of the Palo Verdes Valley. In 1892 the Colorado Irrigation Company was organized to develop the Imperial Valley. This was succeeded in 1896 by the California Development Company, which in turn was acquired by the Southern Pacific Company in 1916. In the fall of 1900 work was started on the Imperial Canal. The headgate of the canal was in California, but because of shifting sand hills, its course was laid through Mexico for more than 50 miles. In granting this right-of-way concession the Mexican Government demanded one-half the volume of water passing through the canal. Only a part of the canal was acutally dug -- for the remainder of the distance the ancient channel of the Alamo River, which once connected the Colorado River with the Salton Sink, was cleared of debris and utilized. Where the Alamo channel recrossed into the United States, control works were constructed to direct the water into irrigation canals. Early in 1901 the first water from this canal reached the Imperial Valley. Within three years more than 700 miles of distribution canals had been built and 75,000 acres of land placed under cultivation.

But the canal builders had failed to reckon with the capricious Colorado. In 1904-05, fed by desert cloudbursts on its tributaries, the river broke through the incompleted diversion structures and following the old channels of the Alamo and New Rivers poured into the Salton Sink. The Salton Sea thus formed was 45 miles in length, 17 miles wide, and 80 feet deep. As the Colorado receded, much of its water again turned south through these river channels to find its way to

the ocean. The flood engulfed the bordering low areas in the Imperial Valley and threatened to destroy the entire irrigation development. It was not until 1907, after several unsuccessful attempts to close the break and the expenditure of $3,000,000, that the Colorado was permanently returned to its natural channel.

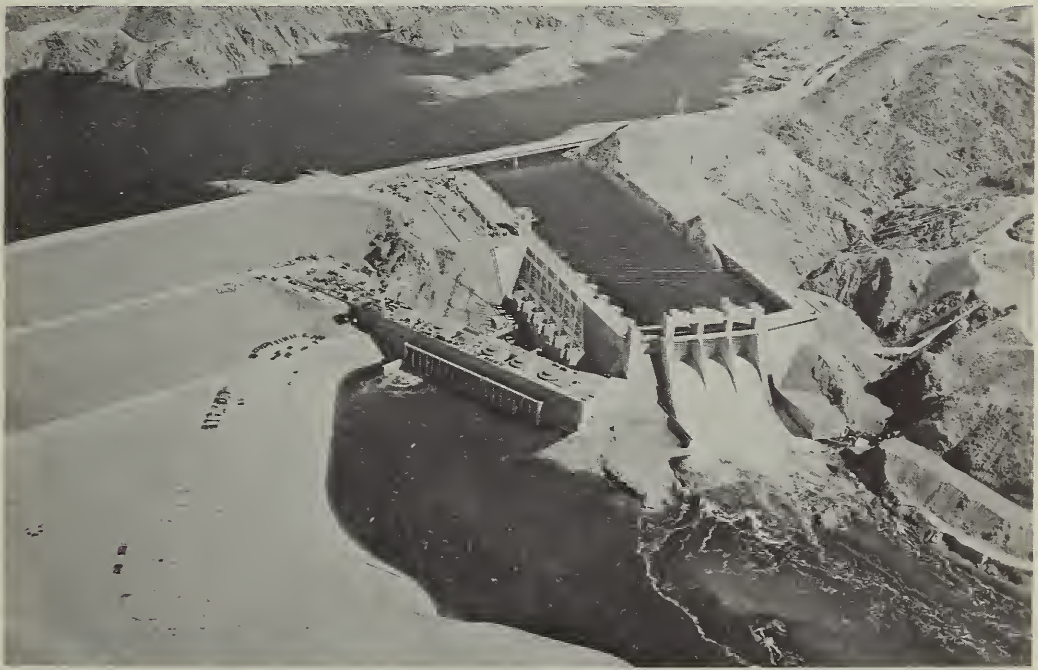
Following this disaster, the Imperial Irrigation District was organized in 1911 to manage the main water facilities and the distribution of water to 13 mutual water companies in the Imperial Valley. In 1922 the facilities of these companies were purchased, and it became the sole responsibility of the Imperial Irrigation District to provide water for irrigation, and to take necessary steps for flood control and drainage works. In the meantime action was started to have a dam constructed on the lower Colorado River that would control flood waters and conserve them for beneficial use. This led to the introduction in Congress of a series of bills which eventually resulted in the Boulder Canyon Project Act of 1922, and its passage, after much controversy, in December 1928.

The Boulder Canyon Project Act provided for the construction of what is today Hoover Dam and the All-American Canal. It fixed priority of use of the dam and reservoir: 1. for river regulation, improvement of navigation and flood control; 2. irrigation and domestic use; 3. power. It required the State of California, by legislative action, to limit its use of Colorado River water to 4,400,000 acre-feet per year plus one-half of any excess or surplus water not apportioned by the Colorado River Compact.

Disagreement among the Colorado River Basin States over the use of Colorado River water resulted in a series of meetings which culminated in the signing of the Colorado River Compact in 1922. This compact did not apportion the water among the states as originally contemplated. It did, however, apportion the water between the Upper and Lower Basins. The division boundary between the two basin areas runs through a point on the Colorado River known as Lees Ferry.

(16) HOOVER DAM

Hoover Dam in the Black Canyon of the Colorado is the highest dam (726 feet) in the world. Lake Mead, lying behind the dam, is 115 miles long with a capacity of 31,000,000 acre-feet of water.



(17) DAVIS DAM

Located 67 miles downstream from Hoover Dam, was completed in 1952. Height 200 feet, length 1,600 feet. Its reservoir, Lake Mojave, has a capacity of 1,820,000 acre-feet.

(18) PARKER DAM

Parker Dam, situated 155 miles downstream from Hoover Dam, provides a storage reservoir, Lake Havasu (capacity 717,000 acrelfeet), from which water is taken into the Colorado River Aqueduct.

(19) IMPERIAL DAM

The fourth great dam on the lower Colorado is located 18 miles northeast of Yuma, Arizona. The river water here passes through a series of desilting basins before entering All-American Canal.

Under the terms of the Colorado River Compact each basin was allotted in perpetuity for beneficial consumptive use, 7,500,000 acre-feet of water annually. In addition to the above apportionment the Lower Basin was given the right to increase its beneficial consumptive use by 1,000,000 acre-feet yearly.

In 1923 the legislatures of all the basin states, except Arizona, ratified the compact. The Arizona Legislature gave its approval in 1944.

In 1945 the United States Senate ratified a water treaty between the United States and the Republic of Mexico guaranteeing the latter country 1,500,000 acre-feet of Colorado River water annually.

Hoover Dam in the Black Canyon of the Colorado River 25 miles southeast of Las Vegas, Nevada, was constructed in the years 1931-35. It is the highest dam (726 feet) in the world. Behind it lies Lake Mead (115 miles long), the largest reservoir in the United States. The power plant, located below the dam, contains 17 units capable of producing 1 1/3 million kilowatts of electricity -- sufficient to supply the normal domestic needs of 7 1/2 million persons. Ninety percent of the power produced goes to Southern California over hundreds of miles of high-voltage transmission lines. The total estimated cost of Hoover Dam and power plant is $173,000,000, which will be repaid to the Federal Government from power sales.

The All-American Canal, completed in 1940, furnishes water for irrigation and domestic use to the Imperial and Coachella Valleys. Its intake is at the west end of Imperial Dam on the Colorado River from which point the main canal extends westward for 80 miles parallel to the Mexican Border lying a few miles to the south. The main canal is primarily an earth canal with a number of water-drops which provide power for the generation of electricity. The capacity of the canal varies from about 15,000 cubic feet per second at the intake to 2,600 cubic feet per second at its present westerly terminus. The Coachella Branch of the canal skirts the

eastern edge of the Imperial Valley and runs in a northwesterly direction to Indio in the Coachella Valley where it turns south toward the head of the Salton Sea, a total distance of 123 miles. The cost of the All-American Canal irrigation project, including the Coachella Branch, is estimated at $66 million, of which $52 million is covered by repayment contracts with the Federal Government.

Today the unpredictable Colorado River is further shackled by the new Davis Dam located 67 miles below Hoover Dam and about 10 miles north of the point where the state boundaries of Arizona, California, and Nevada meet. Davis Dam is an earth and rock-fill structure 200 feet high and 1,600 feet long. Its reservoir, Lake Mojave, has a capacity of 1,820,000 acre-feet and extends upstream to the tailrace of the Hoover Dam power plant. This multiple-purpose dam was constructed by the Bureau of Reclamation during the period 1942-52 at a cost of approximately $119 million for water storage, power generation, and river regulation. The power plant will provide a billion kilowatt-hours of electric energy annually for use in the neighboring states.

WATER FOR THIRSTY LANDS

Agriculture in Southern California is an intensive, specialized, commercial undertaking with many problems which depends almost entirely upon irrigation water. In the eight counties of the Southland there are 42,500 farms with a total area of 5 1/2 million acres. Of this total number of farms 30,000, or 70 percent, are irrigated farms containing 3 1/2 million acres. The total acreage of land irrigated each year approximates 1 1/4 million acres.

Southern California ranks high among the agricultural regions of the country, and the annual value of crops produced on its farms exceeds $500,000,000. On the basis of the value of farm products sold, three Southland counties (Los Angeles, Imperial, and Orange) are in the first 12; seven counties are in the first 25; and all eight counties are in the first 30 leading agricultural counties in the United States.

(20) ALL-AMERICAN CANAL

From Imperial Dam the canal runs westward for 80 miles parallel to the Mexican border; provides water for the irrigation of 425,000 acres in the Imperial Valley, and also for hydroelectric power.

(21) IMPERIAL VALLEY

Known as "America's Winter Garden". Largest irrigated area in western hemisphere -- 5,000 farms, 500,000 acres under cultivation. Principal crops: alfalfa, cotton, grain, sugar beets, flax, melons.

(22) COACHELLA BRANCH, ALL-AMERICAN CANAL
Winding like a snake through the desert to the Coachella Valley at the head of the Salton Sea, a total distance of 123 miles. U. S. Highway 60-70 straight black line across center.

(23) COACHELLA VALLEY
A beautiful green oasis set in desert surroundings. Noted for its unique date industry and out-of-season fruits and vegetables. The canal provides irrigation water for thousands of acres.

The Coastal Plain, extending from Santa Barbara to San Diego, has a mild, equable climate suitable for the growing of many kinds of fruits, vegetables, and field crops. Here is found the major citrus area (over 225,000 acres) of the State which produces almost all the lemons grown in the United States, and a large portion of the oranges. Other important crops are walnuts, avacados, grapes, berries, and many varieties of vegetables. The large Southland population consumes a great quantity of agricultural products, many of which have to be shipped in from other regions. In recent years heavy inroads have been made on farming areas by suburban development near the large cities and towns. Since the water available for crop lands is already fully utilized, there is little opportunity for further expansion of irrigation agriculture until new water supplies are developed.

The Imperial Valley, known as "America's winter garden", is the largest irrigated area in the western hemisphere. It includes some 900,000 acres, of which more than 500,000 acres are under cultivation. The All-American Canal provides the valley with an adequate and dependable supply of water from the Colorado River. Truck crops, such as lettuce, carrots, cantaloupes and watermelons, tomatoes, and many other vegetables are grown in the fall, winter, and spring when supplies from other regions are lacking. Large acreage is also devoted to field crops of alfalfa, cotton, barley, sugar beets, and flax. All of the land in the Imperial Irrigation District, for which irrigation water is now available, is in private hands. Extension of irrigation to other areas in the valley, and further development of the power possibilities of the canal are contemplated.

The Coachella Valley, northwest of the Salton Sea, includes 135,000 acres with about 47,000 acres under cultivation. The climate is similar to the Imperial Valley and the principal crops are dates, table grapes, citrus, and out-of-season vegetables, and field crops. In the past water for irrigation was obtained principally from deep wells. At present the Coachella Branch of the All-American Canal serves about 75,000 acres; ultimately it will furnish water for 105,000 acres of crop lands.

The Palo Verdes Valley, lying along the Colorado River near Blythe, covers more than 120,000 acres of which 67,000 acres are under cultivation. The main crops of the valley are cotton, alfalfa, cantaloupes and watermelons, lettuce and other vegetables, and grain. Water for irrigation is supplied by a gravity canal from the Colorado River.

The Yuma Irrigation Project, in addition to serving lands in Arizona, covers some 25,000 acres in California bordering the Colorado River, of which about 10,000 acres are now under irrigation.

MORE WATER FOR MORE MILLIONS

Colorado River Aqueduct

Many years before Hoover Dam was built water engineers in Southern California had been casting hopeful eyes toward the Colorado River. With the phenomenal growth of the Southland it was becoming increasingly evident that there would soon be need of new importations of water. The Colorado appeared to be the only feasible source, providing its flood waters could be regulated and conserved. So in 1924 the City of Los Angeles filed application to appropriate 1,500 cubic feet per second [2] of water from the Colorado, and carried on intensive studies and surveys of routes by which the water could be brought to the city. In 1926 the City of San Diego filed a similar application for 155 cubic feet per second of Colorado River water.

The Metropolitan Water District of Southern California, comprising Los Angeles and 10 other cities (later increased to over 50) was incorporated in 1928. The following year a board of review was appointed to investigate proposed routes for an aqueduct. They selected the Parker route which started on the Colorado River 16 miles above Parker, Arizona. In 1931 the people of the Metropolitan Water District voted a bond issue of $220,000,000 and construction work on the aqueduct was begun in 1933 and a year later on Parker Dam.

(2) One cubic foot per second for 12 hours equals one acre-foot.

The primary storage for the District's water supply is in Lake Mead at Hoover Dam. This stored water is delivered in the river 155 miles downstream at Lake Havasu, created by Parker Dam, from which the water is taken into the Colorado River Aqueduct. Parker Dam and power plant were built by the Bureau of Reclamation for the Metropolitan Water District which paid for the entire cost of the dam and approximately one-half the cost of the power plant. The United States retains ownership of the dam and one-half of the power privileges.

The Colorado River Aqueduct is a gigantic engineering achievement. From the intake at Lake Havasu the aqueduct runs 242 miles in a westerly direction across the Colorado Desert, skirts the Little San Bernardino Mountains, crosses San Gorgonio Pass east of Banning, passes under the San Jacinto Mountains by tunnel and ends at Lake Mathews near Riverside.

The topography of the country through which the aqueduct passes divides the project into two sections. The first extends from the Colorado River 127 miles to the Hayfield pump-lift and tunnel. Within this distance the water is lifted 1,617 feet by five electric pumping plants. From the Hayfield tunnel the water flows by gravity through the second 115-mile section to Lake Mathews (capacity, 104,000 acre-feet) located south of Riverside. The magnitude of the aqueduct project is shown by the following construction details: 92 miles of 16-foot diameter tunnels, 64 miles of open canals, 54 miles of covered conduits, 29 miles of inverted siphons, and 2 dams and reservoirs. Thirty-eight camps were established on the project, and the maximum daily employment was 8,700 people.

The cost of the Colorado River Aqueduct and Parker Dam and power plant was approximately $230,000,000.

From Lake Mathews aqueduct water is conveyed through 175 miles of pressure lines and tunnels to cities and agencies belonging to the Metropolitan Water District. The main (upper) feeder line runs north from the reservoir to the

(24) WHITSETT INTAKE PUMPING PLANT

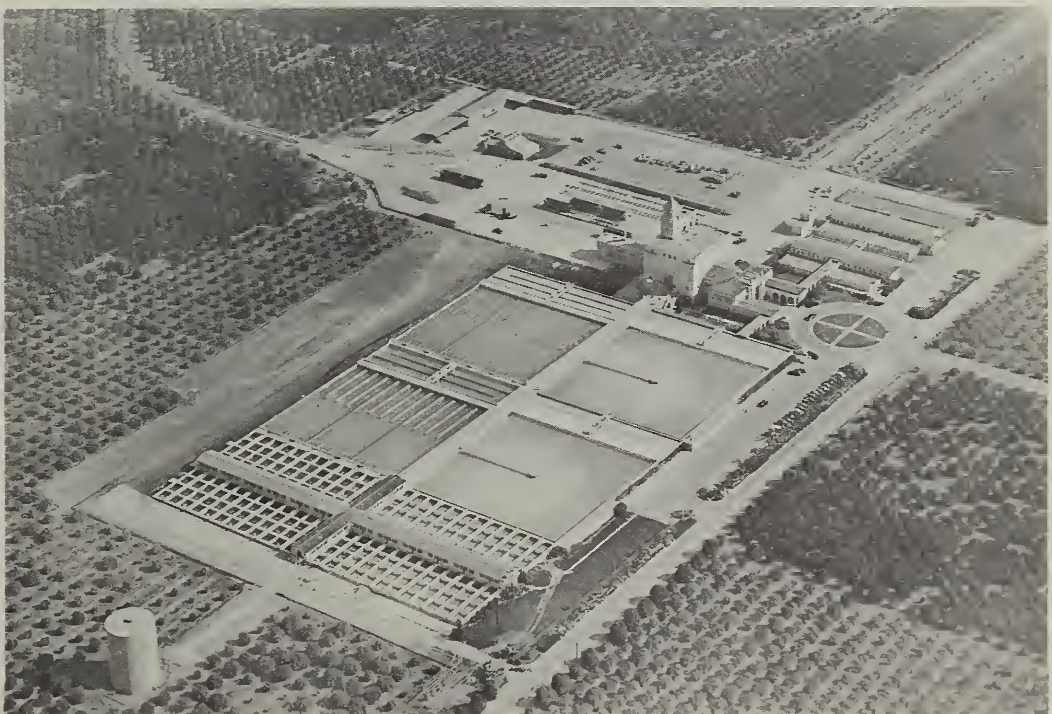
From the aqueduct intake at Lake Havasu the water travels 242 miles to Southern California. Five pumping plants lift the water 1,617 feet over the mountains; thence it flows on by gravity.

(25) AQUEDUCT CANAL

Through treeless mountains, across barren valleys and sunbaked deserts the water is carried in 117 miles of concrete-lined canals and conduits, and many miles of tunnels.

(26) LAKE MATHEWS

Principal storage reservoir for Colorado River Aqueduct water. From this reservoir feeder lines carry water to cities and lands in the Metropolitan Water District of Southern California.



(27) WEYMOUTH SOFTENING & FILTRATION PLANT

Colorado River water delivered to domestic consumers is first softened and purified. This plant, located near La Verne, can handle 200,000,000 gallons of water per day.

SOUTHERN CALIFORNIA
SOURCES OF WATER SUPPLY
NEVADA
CALIFORNIA
ARIZONA
MEXICO
Pacific Ocean
CENTRAL VALLEY
MOJAVE DESERT
COLORADO DESERT
IMPERIAL VALLEY
Lake Tahoe
Mono Lake
Grant Lake Resvr.
Crowley Lake
BISHOP
AQUEDUCT INTAKE
SIERRA NEVADA RANGE
MT. WHITNEY 14,495
HAIWEE RESVR.
DEATH VALLEY
PANAMINT RANGE
FRESNO
BAKERSFIELD
LOS ANGELES AQUEDUCT
MOJAVE
TEHACHAPI MTNS.
BARSTOW
VICTORVILLE
LAS VEGAS
Lake Mead
HOOVER DAM
Lake Mojave
DAVIS DAM
KINGMAN
NEEDLES
Lake Havasu
COLORADO RIVER
PARKER DAM
COLORADO AQUEDUCT
GRAND CANYON
SAN LUIS OBISPO
SANTA MARIA
LOS PADRES NATIONAL FOREST
SIERRA MADRE MTNS.
Santa Ynez River
CACHUMA RESVR.
GIBRALTAR RESVR.
JUNCAL RESVR.
SANTA YNEZ MTNS.
POINT CONCEPTION
SANTA BARBARA
VENTURA
Santa Clara River
SAN FERNANDO RESVR.
HANSEN BASIN
SANTA MONICA MTNS.
SEPULVEDA BASIN
GLENDALE
LOS ANGELES
SANTA MONICA
LONG BEACH
PASADENA
ANGELES NATIONAL FOREST
SAN GABRIEL DAM NO. 1
MORRIS DAM
FILTRATION PLANT
SANTA FE BASIN
Rio Hondo
San Gabriel River
Santa Ana River
PRADO BASIN
Lake Mathews
SANTA ANA
NEWPORT BEACH
CLEVELAND NATIONAL FOREST
SANTA ANA MTNS.
CAJON PASS
Lake Arrowhead
Big Bear Lake
SAN BERNARDINO
SAN BERNARDINO MTNS.
SAN BERNARDINO NATIONAL FOREST
RIVERSIDE
LITTLE SAN BERNARDINO MTNS.
Whitewater River
PALM SPRINGS
SAN JACINTO MTNS.
SANTA ROSA MTNS.
INDIO
COACHELLA VALLEY
DESERT CENTER
HAYFIELD RESERVOIR
CHUCKAWALLA MTNS.
GRANITE MTNS.
COACHELLA BRANCH
ALL AMERICAN CANAL
CHOCOLATE MTNS.
BLYTHE
PALO VERDE VALLEY
Salton Sea
-248 Feet Below Sea Level
Alamo
New River
BRAWLEY
SUPERSTITION MTNS.
EL CENTRO
CALEXICO
MEXICALI
IMPERIAL CANAL
IMPERIAL DAM
LAGUNA DAM
YUMA
Santa Margarita River
San Luis Rey River
SAN DIEGO AQUEDUCT
Lake Henshaw
OCEANSIDE
HODGES RESVR.
EL CAPITAN RESVR.
SAN VICENTE RESVR.
San Diego River
Sweetwater River
SWEETWATER RESVR.
LOWER OTAY RESVR.
BARRETT RESVR.
MORENA RESVR.
LAGUNA MTNS.
SAN DIEGO
TIJUANA
Tijuana River

foothills of the San Gabriel Mountains, thence west to Pasadena, a total distance of 61 miles. The Morris Dam and reservoir on the San Gabriel River provides emergency storage above the feeder line to which it is connected. Three main branches, with laterals, extend from the upper feeder line south and west to the coast, and supply water to the Los Angeles, Santa Monica, Palo Verdes, Long Beach, and Santa Ana Districts and adjoining areas. The water delivered to domestic consumers first passes through a large softening and filtration plant near La Verne which is capable of handling more than 200 million gallons per day.

San Diego Aqueduct

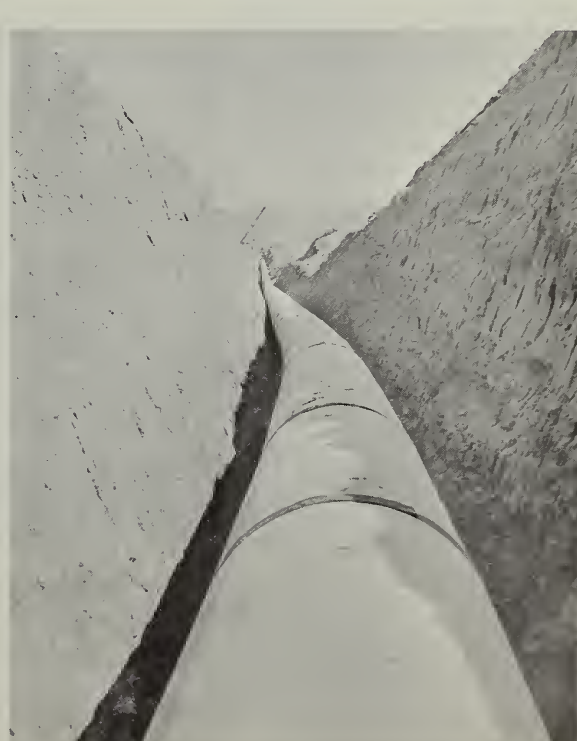
World War II created an emergency in the water supply of San Diego and surrounding communities. After the outbreak of hostilities in Europe in 1939 San Diego became a center of military and naval expansion, and the population of San Diego County increased from 289,000 to more than 500,000, exclusive of military personnel, in the period 1940-1946. A special committee was appointed by President Franklin D. Roosevelt to study the water situation, and it recommended the immediate construction of an aqueduct connecting with the Colorado River Aqueduct, since the Colorado River water offered the only dependable supplemental water supply. In 1944 the San Diego County Water Authority, comprising five cities, three irrigation districts and one public utility was organized to secure additional water supplies from outside the county. In December of that year an emergency appropriation was made available by the Federal Government for construction of an aqueduct. The Bureau of Reclamation prepared the plans for the aqueduct, and the U. S. Navy contracted the work in 1945.

The San Diego Aqueduct is a gravity flow conduit that taps the Colorado River Aqueduct at the west portal of the San Jacinto tunnel, and extends southward for 71 miles to the San Vicente reservoir of the San Diego water system. A small regulatory reservoir is located two miles from the take-off point. The main aqueduct is reinforced concrete pipe varying in diameter from 96 to 48 inches, together with seven tunnels

A giant concrete pipeline, 70 miles long, brings precious water from the Colorado River Aqueduct to the San Diego region which has long suffered from drought. A second barrel is under construction.

(28) A WATER LIFE-LINE

The initial flow of Colorado River water from the San Diego Aqueduct into San Vicente Reservoir November 24, 1947. View from inside the aqueduct.



(29) JOURNEY'S END

totaling 4 1/2 miles in length. From the aqueduct the La Mesa-Sweetwater and Fallbrook-Oceanside branch lines, each 16 miles long, deliver water to the cities and agencies of the San Diego Water Authority. The aqueduct was completed on November 24, 1947 and has been operated at full capacity since that time.

Despite the importation of Colorado River water, San Diego County still faced a serious shortage in its over-all supply. This was due to an increase in population and industry as a result of the Korean situation; the continuation of the drought that started in 1945; and the lack of runoff from local watersheds which caused a decrease in local water reserves.

To alleviate this water shortage an emergency appropriation was secured from Congress in 1951 for the construction of a "second barrel" to the San Diego Aqueduct, and contracts for the work were awarded in the fall of 1952. The project was planned and is being directed by the Bureau of Reclamation; the funds provided by Congress were administered by the Navy Department.

The second barrel, running parallel to the main aqueduct, is 61 miles long, exclusive of tunnels constructed for the first barrel, and consists of concrete pipe varying in diameter from 75 to 48 inches. It was officially dedicated on October 2, 1954.

The estimated cost of the original San Diego Aqueduct is $14,125,000; that of the second barrel, $18,000,000. Repayment of these costs to the Federal Government will be made over periods of 30 and 40 years, respectively.

With the second barrel in operation, the San Diego Aqueduct will have a delivery capacity of approximately 180 cubic feet per second of Colorado River water. This increased supply will be distributed to member agencies of the San Diego County Water Authority which are now ten in number with a total area of 127,000 acres and a population in excess of one-half million. Five new areas have also been formed recently and are in process of annexation to the authority.

(30) A BIG CITY FIRE

A tremendous amount of water is often used to extinguish a big fire. The apparatus used on this fire can throw 720,000 gallons of water per hour -- enough to supply a family of 5 people for 2 years.

(3 1) WASHING A STREAMLINER

To wash a train of 16 cars and 3-unit Diesel engine takes 16 minutes and 7,300 gallons of water. A major railroad in Los Angeles uses one million gallons of water per month for washing equipment.

(3 2) A TROPICAL BEACH

Large artificial "lakes" are used by the major studios in Hollywood as a setting for many spectacular water scenes in motion pictures.

(33) FURROW IRRIGATION

Nearly 225,000 acres of citrus groves in Southern California are dependent on irrigation water for the annual production of oranges, lemons, and grapefruit valued at more than $150,000,000.

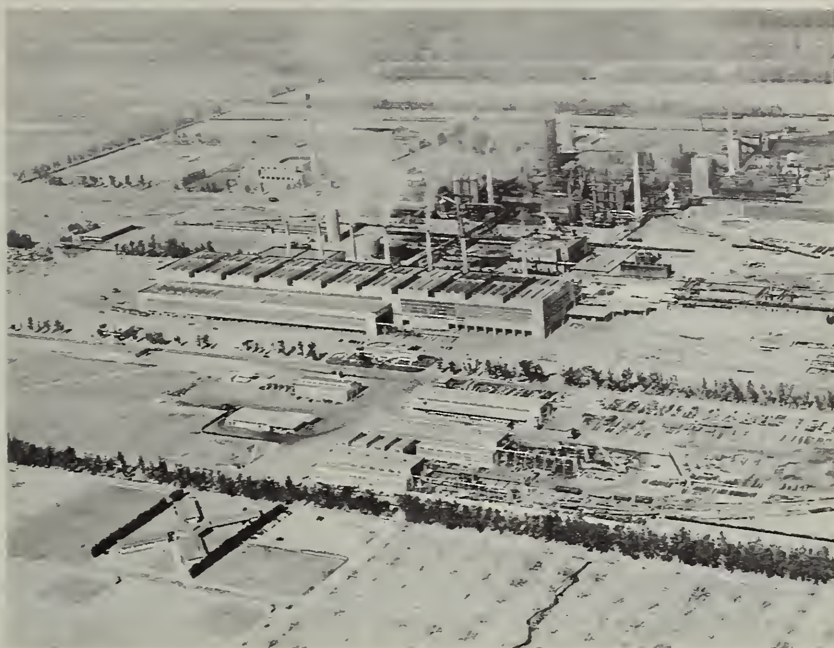
(34) OVERHEAD IRRIGATION

Overhead irrigation of citrus groves, orchards, vineyards, pastures, truck and field crops is common practice in the Southland. It is claimed that this method saves water and reduces erosion.

WATER HAS MANY USES

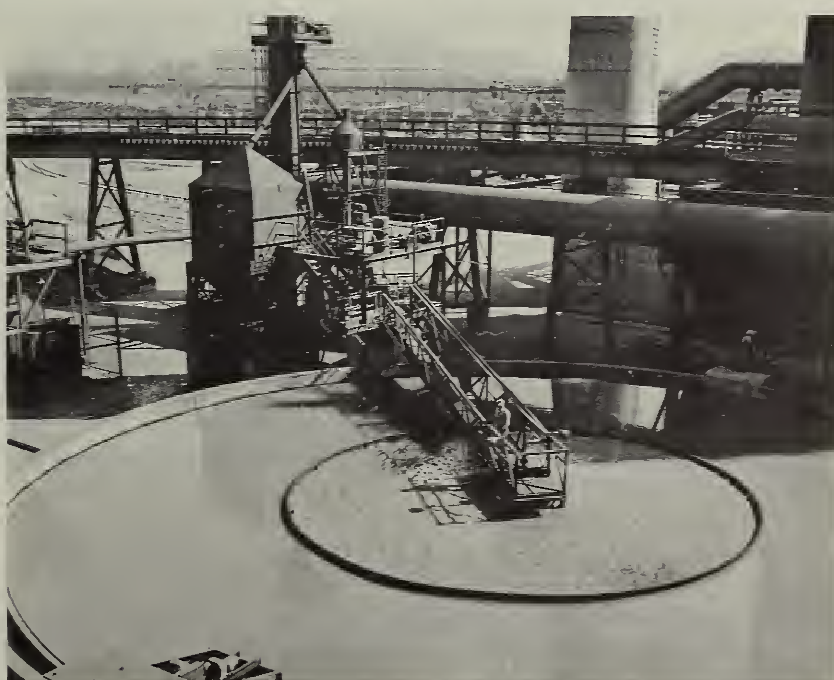
(35) PUDDLE IRRIGATION

Flooding, or puddle irrigation, is generally used to irrigate date groves in the Coachella Valley -- the center of this semi-tropical industry which annually produces a date crop valued at $5 million.



(36) KAISER STEEL PLANT

Many industries are large users of water. Every minute of the day 80,000 gallons of water circulate to all parts of this plant. Only 3 percent of this total is new water added to replace evaporation loss.



(37) RECLAIMING USED WATER

The Kaiser Corporation spent $3 million for machinery to reclaim water used in their steel mills. The clari-flocculator shown removes the solids from the water and the remaining clear water is re-used.

PART 2. FORESTS TO FAUCETS

NATURE'S STOREHOUSE

A Chinese philosopher once said: "To rule the mountain is to rule the river." This ancient proverb aptly describes the problem of water in Southern California. For whether it comes from the nearby mountains, the distant Sierra Nevada, or the far away Rockies, it comes from the forest -- the birthplace of the water which irrigates orchards and croplands, and gushes each day from a million faucets in the Southland. This fact is little known to many people who use the water.

The Colorado River is a good example. Many of the important tributaries forming this great river originate in the mountain regions of 23 national forests in five Western States. These forests form a gigantic watershed of more than 30,000,000 acres -- equal to almost one-third of the total area of California. The Los Angeles Aqueduct receives practically all its water from the Inyo National Forest located along the snow-capped slopes of the High Sierra. Even closer to home are the mountain regions of the Angeles, Cleveland, Los Padres, and San Bernardino National Forests, which comprise the watersheds of streams that flow onto the Southern California coastal plain. It is estimated that more than three million people, both city and rural population, obtain their water supply either directly or indirectly from the watersheds of these four national forests.

There is a wide gap between the number of people in Southern California and the local water supply. Fifty-three percent of the total population of the State live in this region which has only two percent of the water originating in California.

The water supply of the Southland coastal plain comes primarily from the rain and snow that falls on national forest watersheds in the mountains and foothill areas, supplemented by ground water originating as rainfall on the valley floor. But not all of this water is available for use by man. Some

of it is wasted through uncontrolled runoff into the ocean, and there are additional water losses from evaporation and transpiration by trees, shrubs, and other native vegetation. The water that is left and is available as stream flow, or is obtained by pumping from underground basins, is not sufficient to meet the needs of the region for domestic use, industry, and agriculture.

In early days the Los Angeles River, which heads in the nearby Angeles National Forest, was the main source of water supply for the pueblo, and later for Los Angeles city. Today this river furnishes 26 percent of the city's water; the Los Angeles-Owens River Aqueduct provides 70 percent; and the Colorado River, at present, only four percent. However, a recent major connection between the Los Angeles water system and the Colorado River Aqueduct at the new Eagle Rock reservoir will enable the city to draw more heavily on its share of Colorado River water. From this storage and regulating reservoir a 68-inch diameter pipeline, with a capacity equal to almost one-half of the city's present daily water requirements,will extend westward 10 miles to the Hollywood reservoir. This project, estimated to cost $7 million, will be one of the most important water life lines of the city.

Despite large importations of water from distant sources, the local water supply from the nearby national forests will always be of high value to the people of the Southland because of its: 1. cheapness -- imported water may cost from two to four times as much as local water; 2. availability -- many areas do not have access to imported water and must, therefore, depend on local water; and 3. dependability -- the protected watersheds of the national forests are an important source of water for replenishing the underground reservoirs, from which large quantities of water are pumped for domestic, irrigation, and industrial use.

HOW WATERSHEDS FUNCTION

Everyone who uses water in his daily needs, in industry, or in crop production should have a better understanding of what watersheds are -- how they receive and deliver water,

(38) FOREST WATERSHEDS
The water that feeds the streams and reservoirs of the Southland and helps to replenish the underground storage basins comes primarily from the mountain watersheds in the national forests.

(39) ORANGE GROVES & SNOWY PEAKS
Many cities and towns and thousands of acres of citrus groves lie in proximity to the national forests and depend upon these forests to supply their daily water needs.

(40) CHAPARRAL FORESTS

Chaparral, composed of chamise, greasewood, and sagebrush intermixed with open stands of oaks and shrub species form an elfin type of forest on the lower mountain slopes of the Southland.

(41) CONIFEROUS FORESTS

At elevations of 5,000 to 8,000 feet in the national forests are open stands of pine, spruce, and fir. Little cutting is done in these forests except to remove old, diseased, and defective trees.

(42) FOREST CAMPGROUND
The four national forests of Southern California offer many opportunities for outdoor enjoyment. The Forest Service has improved 450 campgrounds for the comfort and convenience of visitors.

(43) TV INVADES THE FORESTS
Many mountain peaks, such as Mt. Wilson in the Angeles National Forest, offer vantage points for television and radio towers from which programs can be broadcast to millions of people.

and to what extent man can influence runoff and soil erosion through treatment of watershed lands. This is particularly true of people who live in Southern California, where mistreatment of mountain watersheds has often caused loss of life and great property damage on the valley lands below.

A watershed is the drainage basin from which a stream receives its water. It may be small, like Fern Canyon near Pasadena, or it may cover parts of several states, like the Colorado River watershed. It may include not only mountains, but foothills, farm lands, and cities and towns. The entire Southland is made up of watershed units which feed the streams that furnish water for countless uses.

Soil and plant cover are two important parts of a watershed. The soil is the product of ages of rock weathering and the activities of plants and animals. The leaves and branches of trees, shrubs, grass, and other plants growing in the soil, fall to the ground and form a mantle of humus which protects the soil, increases the amount of water that seeps into the ground, and thus reduces the amount of surface runoff and soil erosion. The roots of plants, and the burrowing animals and insects form channels in the soil that allow the water to sink deep into the ground. Plant cover, therefore, is the key to the development and maintenance of soil and the humus-mantle on a watershed.

Watersheds dispose of precipitation in two ways -- by seepage flow and by overland flow. Seepage flow is the water that reaches springs and streams after percolating through the soil and broken rock under it. After the soil has become soaked, the surplus water in it seeps slowly to the underground rock to gradually work its way to springs and into streams. Overland flow, as the name implies, is water that runs off over the surface of the land directly into the streams. Many tests have shown that the capacity of a watershed to absorb rainfall depends on many conditions, but to a very large extent on the kind of plant cover and the amount of humus on the surface of the ground.

A well-managed watershed with undisturbed soil and a heavy cover of plants and humus to protect the ground yields a good

steady flow of clear water. But if the plant cover is removed by fire, overgrazing, or other harmful practices, there is nothing left to protect the soil. The raindrops beat upon the barren ground like a million triphammers, sealing the soil surface and creating a "pavement" over which the water races. Fed by water from countless small gullies the flood gathers in volume as it sweeps down the mountain side, scouring out the stream beds, and spreading mud, boulders, and debris over orchards, farm lands, and towns in the valleys.

OPERATION WATERSHED

Southern California has a serious flood control problem. In many parts of the region densely settled urban and suburban areas lie close to the steep and rugged mountain ranges from which, all too frequently, destructive floods pour down upon the coastal plain. The damage wrought by these floods, especially when they come from fire-swept mountain watersheds, is appalling. The problem of management is, therefore, twofold: 1. the protection and improvement of upstream watersheds, and 2, the control of water and erosion debris downstream.

Upstream Watersheds

Many uninformed people consider the chaparral cover of the mountains within the national forests of the Southland as "worthless brush". But old-time valley residents, irrigation farmers, and water officials know full well the important place chaparral holds in the water economy of the region. The vital function of chaparral is to retard water flow and erosion, and to increase the amount of water that percolates into the soil. So the main purpose of watershed management is to maintain the forest cover for the maximum performance of these functions.

The Forest Service program for management of watersheds in the national forests is divided into four parts, each essential to all the others. These are:

1. Fire control for protection of the cover.
2. Plant cover improvement.
3. Road improvement to reduce erosion.
4. Channel improvement.

Fire Control...

The fire situation in the mountains of Southern California is the most hazardous in the United States. Rough terrain, hot weather, and dry winds, intensive public use, highly inflammable cover, and rapid spread of fire makes control a tremendous problem. In the past 30 years about one-half of the more than three million acres in the national forests of the Southland have been swept by fire. Ninety percent of all these fires were due to human carelessness. In more recent years, however, improved methods of fire control, new types of firefighting equipment and extensive use of airplanes, helicopters and radio have enabled the protection agencies to hold fire losses to a low acreage, except in years of extremely high and long continued fire hazard, such as occurred in 1953.

Fire control measures designed to protect mountain watersheds are:

1. Public education; no smoking regulations, and closure of critical areas to public use.

2. An adequate system of fire lookouts; communication by radio and telephone, and trained firefighters located at strategic points.

3. Speed of attack through better road and trail facilities; use of smokejumpers, and helicopter-transportation of men and equipment to inaccessible areas.

4. Rapidity of control through development of water sources, cleared firebreaks, use of trucks with pumper-tanker apparatus, and other power-driven and manual equipment.

THE FORESTS' PRIME EVIL

(44) FIRE IN THE MOUNTAINS

The Wheeler Springs fire in Los Padres National Forest destroyed 25,000 acres of valuable watersheds which furnished water to cities and farms. This fire endangered homes in the town of Ojai.

(45) A RAGING INFERNO

In the past 30 years one-half of the valuable watershed areas in the national forests of the Southland have been swept by fire. Human carelessness caused 90 percent of these fires.

(4 6) FIRE'S AFTERMATH

A forlorn family sadly search the ruins of their home destroyed by a forest fire.

(47) EYES OF THE FOREST

Officers stationed on 46 primary lookouts in the national forests of Southern California keep a constant watch for fires during the long danger season. Lookouts report fires by radio and telephone.

(48) FIREFIGHTERS

Toil and sweat with axe and shovel amid smoke and flame is still the common and sure way to control a forest fire. More than 2,000 men are often employed on a large fire.

(49) SMOKEJUMPER

When fires occur in inaccessible parts of the mountains, smokejumpers who are specially trained and equipped are transported by airplane and parachuted to the scene of the fire.

(50) HELICOPTER SCOUTING A FIRE

Helicopters are extensively used by the Forest Service to scout big fires; carry men, food, and equipment to critical points on the fire; and to transport injured men to camp for medical aid.

Plant Cover Improvement...

Severe fires destroy the plant cover of watersheds and cause excessive soil erosion if the cover is not promptly re-established. The simplest and cheapest treatment of burned areas is the sowing of mustard and grass seed by hand, airplane, or helicopter. These plants grow rapidly if climatic conditions are favorable and provide a cover for the bare soil until native vegetation regrows. Seed-spot sowing of shrubs and herbs, and the planting of cuttings of sprouting shrubs is also done on slides and barren areas on mountain slopes to help stabilize the soil.

Road Improvement...

Road construction in the mountains frequently results in heavy erosion from cut slopes, fills and overcast areas, and the slipping of great masses of soil and rock into the stream channels. Faulty drainage must first be corrected and adequate culverts provided to handle runoff water. Bare earth slopes are next stabilized by means of contour trenches, about four feet apart, in which thick "cables" of brush are partly buried and supported on the lower side by stakes. Erosion on slopes can be temporarily retarded by the sowing of cereal grains and other quick-growing annuals. This must be followed by the planting of more permanent vegetation, such as cuttings of certain shrubs, and nursery-grown seedling trees suitable to the location.

Channel Improvement...

Enormous amounts of soil, rock, and debris are carried down mountain stream channels and deposited in reservoirs, or upon the great alluvial fans at the mouth of canyons. Much of this material comes, during storms, from erosion on burned areas and road slopes, from land slides, from the undercutting of banks along the stream channels, and from the scouring of the streambeds by floods.

The purpose of channel improvement work is to stabilize the channel and the debris in the channel, and to reduce side

cutting and undermining of the slopes caused by the action of the stream against its banks. Channel treatment consists of building a series of barriers of concrete, rock, metal, or earth across the stream bed. The size of each barrier depends on local conditions. In time the channel behind the barriers becomes filled with debris on which shrubs and trees often grow in profusion. Other forms of channel improvement include the building of retaining walls to stop earth slides, and the clearing of log and boulder jams in the stream bed.

Downstream Valley Lands

The coastal plain area of Southern California prior to the installation of control methods and works was subject to great potential flood hazard. These floods moved vast quantities of silt, sand and boulders, and valuable topsoil from agricultural lands to locations where they caused millions of dollars of damage, and had to be removed at great expense.

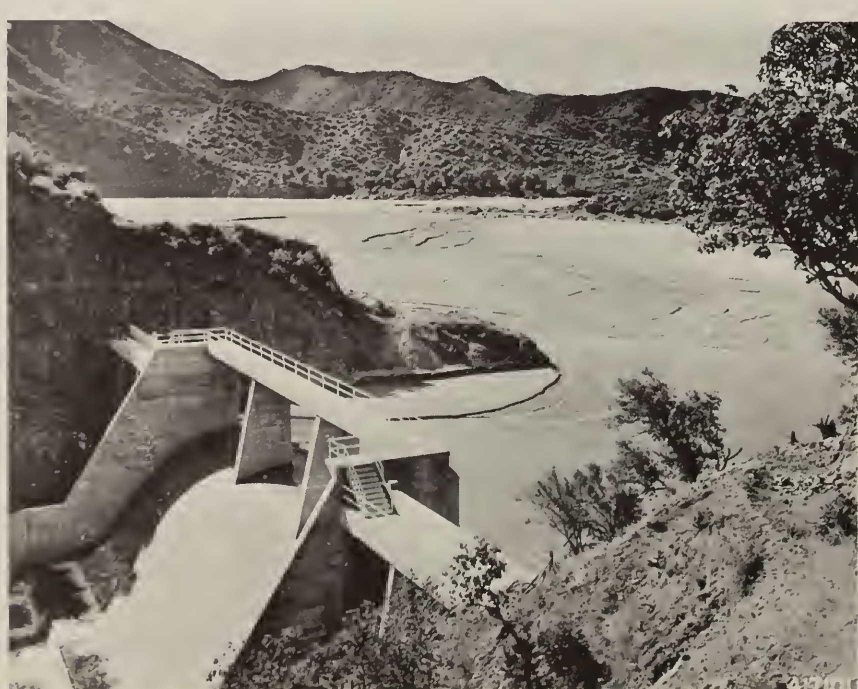
To meet this flood menace a comprehensive flood-control program was put into effect involving Federal, State, County, and other agencies, and the expenditure of large sums of money.

Soil Conservation...

The program on private agricultural and range lands, designed to reduce loss of fertile topsoil through erosion, and to maintain or improve the productive capacity of the soil, is carried on by the Soil Conservation Service, U. S. Department of Agriculture, in cooperation with State and County agencies. This Federal service works chiefly through Soil Conservation Districts organized by farmers under State laws, and locally managed. There are 35 of these districts in Southern California with a total area of 7,700,000 acres of which nearly 5 million acres are in farms. Land planning assistance and technical help is given, on request, to individual farmers of the districts by men trained especially for soil conservation work.

(51) A FIRE-SWEPT SLOPE

Fire killed all the vegetation on this mountain slope and rain has started hundreds of shoestring gullies. The next heavy storm will wash most of the fertile topsoil into the stream below.



(52) DEBRIS CONTROL DAM

Mono Dam in Los Padres National Forest was built to retard sand and debris washing into Gibraltar Reservoir, source of water supply for Santa Barbara. Silt filled the Mono Reservoir in two years.

(53) LOADING HELICOPTER WITH MUSTARD SEED
To renew the plant cover on burned slopes before rains start excessive erosion, mustard seed is sown by hand, airplane, and helicopter over the area -- 5 pounds or 1 million tiny seeds per acre.

(54) HEAVY GROWTH OF MUSTARD
Mustard grows rapidly and provides a temporary soil cover on burned slopes. Dead plants form a dense litter on the ground that retards erosion. Many volunteer plants appear the second year.

On valley lands subject to floods and wind and water erosion remedial operations may include: (a) changes in land use, and in the cultural treatment of the land; contour plowing, ditching and terracing; rotation of crops; use of green manure; planting of trees, shrubs and vines; and (b) construction of small barriers and drainage basins; improvement of stream channels and drainage systems; proper disposal of excess runoff water; small farm reservoirs.

Water Control and Conservation...

The Los Angeles County Flood Control District, the largest of other like districts in the Southland, was created in 1915. It is responsible for the control of flood waters, the conservation of such waters for useful purposes, and the protection from floods of harbors, waterways, highways, life, and property within Los Angeles County.

A "Comprehensive Plan", based on the ultimate flood control and water conservation needs of the area within the Flood Control District, has been prepared. Under this plan the district has constructed or operates 14 regulatory dams, ranging from 33 to 365 feet in height, in the major watersheds of the county; five debris dams, and 29 debris basins which have to be cleaned of debris periodically by mechanical means. More than 140 miles of permanent channel improvements have also been constructed.

The district owns and operates 935 acres of spreading grounds adjacent to stream channels, and cooperates in the maintenance of an additional 1,400 acres of spreading grounds which are the property of municipalities, irrigation districts, and water companies.

Total expenditures of the Los Angeles County Flood Control District to date for flood control and water conservation, approximate $131,000,000 exclusive of drainage district expenditures.

In 1952 the people of Los Angeles County voted a bond issue of $179,000,000 for new storm drain systems which will be constructed, operated, and maintained by the Flood Control District.

(55) ROAD EROSION

Heavy storms and uncontrolled water often cut great gullies and cause heavy landslides on the cuts, fills, and overcast slopes on mountain roads.

(56) STABILIZING ERODED SLOPES

Slopes are stablilized by the building of contour trenches in which are buried thick "cables" of brush supported on the lower side by stakes. Cuttings of shrubs are planted in the trenches.

(57) CONTOUR PLANTING

Contour plowing and terracing permits the irrigation and cultivation of these pepper plants, protected by "hot caps", with a minimum loss of water, or loss of soil from erosion.

(58) STRIP-CROPPING

On this large ranch in the Antelope Valley, straight cultivated strips are used to protect the soil from wind erosion, and curved strips to retard both wind and water erosion.

Flood Protection...

Extensive Federal flood-control programs, designed to provide protection for large metropolitan and urban areas, are the responsibility of the Corps of Engineers, U. S. Army, in cooperation with State and local authorities and Federal agencies. To date in Southern California the Army Engineers have expended more than $200, 000, 000 of Federal funds on flood-control reservoirs, debris basins, and channel improvements for the safe conveyance of river flows.

Major projects completed are: six rolled-fill earth dams forming flood-control basins with a total capacity of 312, 000 acre feet, which control the runoff from 2, 820 square miles. The largest of these dams are:

Los Angeles River Basin: Sepulveda -- length, 15, 443 feet; height, 57 feet. Hansen -- length, 10, 475 feet; height, 97 feet.

San Gabriel River Basin: Santa Fe -- length, 23, 800 feet; height, 92 feet.

Santa Ana River Basin: Prado -- length, 2, 280 feet; height, 106 feet. Brea -- length, 1, 765 feet; height, 87 feet.

Other completed projects: San Diego River -- construction of a leveed flood channel 3. 3 miles long and 800 feet wide near mouth of river. Ventura River levee 13, 000 feet long.

Projects partially completed or planned are:

Los Angeles County Drainage area: Flood-control projects on the Los Angeles and San Gabriel Rivers, Rio Hondo, Ballona Creek and their tributaries, which will protect 325, 000 acres of highly improved and densely populated land subject to flooding. Plans call for the construction of five flood-control basins, 33 debris basins, improvement of 105 miles of main channels and 181 miles of tributary channels, and the reconstruction of many railroad and highway bridges. Total estimated Federal cost $326, 900, 000.

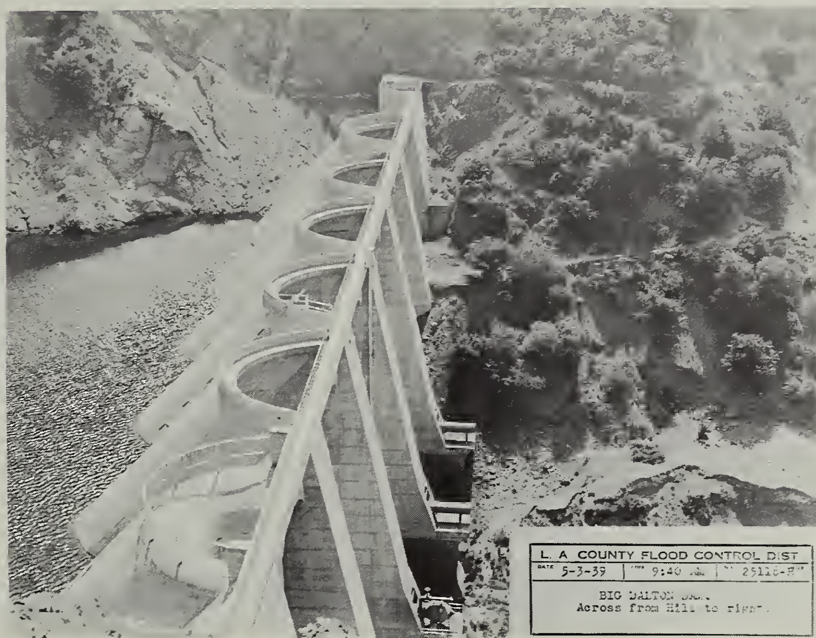
The Whittier Narrows flood-control basin (a coordinated part of the Los Angeles County Drainage Area project) on the main channels of Rio Hondo and San Gabriel River, provides for a rolled-fill earth dam 14,960 feet long and 56 feet high, with a basin capacity of 35,000 acre-feet. Project is 60 percent completed. Estimated Federal cost $34,880,000.

Santa Ana River Basin: Projects that will provide protection for 160,000 acres of overflow areas in Orange, Riverside, and San Bernardino Counties, which include parts of cities, highway and railroad systems, oil fields, and thousands of acres of citrus land. Plans call for several dams, and a number of levee and channel improvement projects. Estimated Federal cost is $76,000,000.

It should be realized that the building of dams and other structures to store and regulate waterflow and prevent floods and erosion, necessary as they are, will not take the place of the natural chaparral cover on the steep mountain watersheds of the Southland. Both are needed to provide adequate water supply, and to safeguard the lives and property of the millions of people who live on the coastal plain.

The demand for engineering works, and the willingness of people to pay for them in taxes or bonds is proven by the fact that in Southern California today there are some 175 great and small dams built for water storage and flood control at a cost of more than $150,000,000. This amount is in addition to the hundreds of millions of dollars spent to import water, and many more millions expended by the Federal Government on flood control and stream improvement projects.

A like demand will also come for more intensive protection and management of the chaparral-covered mountains within the national forests when the people of the region more fully realize how vital these watershed areas are to the economy of the Southland.



(59) FLOOD CONTROL DAM

Big Dalton Dam in the Angeles National Forest is a regulatory dam which conserves flood waters that are later released for use in the valley below. Similar dams are found on other major watersheds.

(60) DEBRIS BASIN

The Pickens Debris Basin desilts the flow from Pickens Canyon. Flood waters enter the inflow at the upper end of the basin, deposit their debris in the basin and pass on through the outflow.

(61) LARGE FLOOD CONTROL DAM AND DEBRIS BASIN
Hansen Dam and Debris Basin regulates the flow of flood water from the 147 square-mile watershed of Big Tujunga River. The dam is 97 feet high and and 1 3/4 miles long; basin capacity, 33,000 acre-feet.

(62) READY FOR ANY FLOOD EMERGENCY
Improved channel of Los Angeles River. This placid little stream can in a few hours, following a torrential storm, become a raging flood many feet deep fraught with power to do inestimable damage.

HIDDEN WATER SUPPLIES

The source of all water supply is the natural precipitation in the form of rain and snow that falls upon the surface of the land. Part of this water finds its way into streams; part passes into the air by evaporation and plant transpiration; and part percolates to basins far underground.

These underground basins, or ground-water reservoirs, are one of the most important sources of local water for domestic use and irrigation in Southern California. The basins are formed by rock barriers many feet below the surface of the land, which retard the flow of underground water to the sea. There are 37 such basins in the Southland, varying in area from a few thousand acres to more than 100,000 acres.

When the development of underground water first began there were many artesian wells on the coastal plain, but these have long since ceased to flow and have been replaced by powerful pump-equipped wells. As the population increased and more acres were put under cultivation the drain on these subterranean basins so lowered the water level and increased the cost of pumping that crop returns in many areas no longer showed a profit. Artificial methods, known as "water spreading" were therefore used to recharge the underground basins more rapidly than by normal percolation of water from streams flowing over the surface of the basins.

Water spreading simply means diverting the stream from its channel and spreading it over adjacent porous soils through which the water percolates to the underground basins. The largest spreading systems are found on the alluvial fan-shaped cones at the mouth of main streams from the mountains; others are located along rivers that flow through the coastal plain. Water is diverted from the stream at the upper end of the spreading system and allowed to flow slowly over the spreading ground, which is interlaced with ditches, dikes, and small dams to retard and distribute the flow. On valley lands, large shallow settling basins, separated by low earth levees are used. But whatever spreading method is employed, it is most important

that the water used be as clear and free from silt as possible, since muddy water will seal the surface of the spreading ground and destroy its usefulness. Herein lies the importance of silt-free water from well-managed mountain watersheds.

Despite water spreading and other measures taken to replenish underground water sources, the demand has far exceeded the supply of water flowing into these basins. This serious and growing shortage has focused attention on the mountain watersheds within the national forests of the Southland which furnish water to these underground basins, and has led to intensive studies of water supply and flood control problems by the Forest Service and other Federal bureaus, State and local water agencies, engineers, and agriculturists.

SCIENCE POINTS THE WAY

The San Dimas Experimental Forest, a branch of the California Forest and Range Experiment Station of the Forest Service, was established in 1934 as the center for scientific watershed studies in Southern California. It is located on the south slopes of the San Gabriel Mountains within the Angeles National Forest a few miles northeast of Glendora. The Experimental Forest covers an area of 17,000 acres of chaparral mountain slopes in the drainage basins of Big Dalton and San Dimas Canyons, and is an extensive outdoor laboratory for research on water problems.

The studies in progress at San Dimas are planned to determine the influence of plant cover, soils, geology, and topography upon the yield of usable water from mountain watersheds, and the magnitude of floods and erosion -- each in relation to rainfall. The results obtained are used to improve methods of mountain watershed management for the greater production of usable water and more effective flood regulation.

Research work on water problems is necessarily slow and painstaking. Detailed records covering a period of 20 years are now available at the San Dimas Experimental Forest to scientists, engineers, and foresters. Gradually, valuable scientific information is being accumulated to round out the life history of a drop of water from the time it strikes the earth until it emerges to serve some need of man.

(63) WATER SPREADING

Underground reservoirs, from which water is pumped, are recharged by allowing the water of a stream to slowly flow through a series of artificial basins from which it percolates into the ground.

(64) RIO HONDO SPREADING GROUNDS

So important are underground reservoirs as a source of water that in the valley regions extensive spreading grounds have been constructed to continually replenish the subterranean supply.

(65) EXPERIMENTAL WATERSHED

Watershed investigations by the Forest Service are centered at the San Dimas Experimental Forest, comprising 17 watersheds totaling 17,000 acres in the San Gabriel Mountains near Glendora.

(66) CLIMATIC STATION

Observations, obtained by instruments shown, include continuous records of rainfall, air temperatures, humidity, wind direction and velocity, evaporation and soil temperatures.

PART 3. LOOKING TO THE FUTURE

POPULATION TRENDS

The population trend in the United States at the present time is toward the West and Southwest. If this continues, California, listed in a recent Census Bureau study as second among states in population (12,087,000 -- July 1, 1953), is destined in the not too distant future to become the most populous state in the Nation.

The eight counties comprising Southern California have played a notable part in the State's growth in population. In the census period 1940-50 the growth in population was 1,979,886 people, or over 53 percent. The total Southland population was 5,652,249 or more than one-half of all the people in California.

The increase or decrease in population of any particular region, during a census decade, is dependent on many unpredictable factors. No attempt has, therefore, been made to forecast future population trends in Southern California. For the statistically minded, the following table, based on percentage of growth, indicates in round figures what the population of the Southland may be in 1960.

Southern California

Percent of Increase (1950-1960)	Total population 1960 (Approximate)
50	8,500,000
40	7,900,000
30	7,350,000
25	7,000,000

THE WATER SITUATION TODAY

Before considering the problem of future water supplies to provide for population gains, let us briefly review the water situation in Southern California as it exists today.

1. The average rainfall of this semiarid region is insufficient to provide adequate water supplies for present domestic, industrial, and agricultural needs. The Southland is now in a drought period, with subnormal rainfall in eight of the last nine calendar years. Most reservoirs are alarmingly low. A severe water shortage is imminent in many areas.

2. The availability of adequate water supplies has played a vital role in the present high level of cultural and industrial development in parts of Southern California, while lack of water has limited development in other sections. A few areas have ample water for many years to come; some have sufficient supply for present needs, but little for expansion; some need additional water to maintain present development, and some have virtually no supply. The cost of obtaining water is, in many cases, the key to its availability. Densely populated areas can afford to supplement local supplies by the importation of water at great cost; sparsely settled areas are definitely limited in the price they can pay for water.

3. Agriculture is suffering from lack of water. The Southland has reached a point where practically all local water, which can be developed at a cost that agriculture can afford, is being utilized, and large amounts of water are being imported to augment local supplies. On the western slope of San Diego County, for example, there are 200,000 acres classified as suitable for growing irrigated crops, of which only about 56,000 acres are under cultivation because of the lack of water. In times of drought, irrigation agriculture is usually the first to feel the pinch for water.

4. Due to excessive pumping for agricultural development and other purposes, the water level of underground basins of the coastal plain has fallen rapidly, and in some localities has reached an acute stage. In the Los Angeles, San Gabriel, and Santa Ana River basins the ground water reserve has been depleted by 6,000,000 acre-feet. In other areas the water level of pumping wells has fallen as much as 50 feet, and some wells have gone dry.

Orange County, one of the leading agricultural areas of the Southland, may be cited as an example of a county that is taking

steps to remedy this situation. In the coastal basin of this county there is an estimated yearly overdraft in ground water supply of 67,000 acre-feet, with an estimated accumulated overdraft of 375,000 acre-feet. To replenish these diminishing underground supplies, the Orange County Water District and other water companies have in the past 4 1/2 years (July 1, 1949 to December 1, 1953) purchased 136,000 acre-feet of Colorado River water from the Metropolitan Water District of Southern California at a cost of $1,500,000. The water thus obtained was sunk into the spreading grounds on the Santa Ana River. In 1953 the State Legislature authorized the Orange County Water District to levy an assessment on each acre-foot of water produced in the district. The returns from this assessment will be used to purchase additional Colorado River water for recharging the underground basins.

5. Another serious problem is the intrusion of salt water into underground basins of the coastal plain bordering the ocean. Here heavy pumping has lowered the ground water level to below sea level, and permitted ocean water to move inland and degrade underground fresh water supplies.

In 1951 the California State Legislature appropriated $750,000 for a program of study and plans to prevent and control this ocean water intrusion. The State Water Resources Board contracted with the Los Angeles County Flood Control District for an experimental field injection project at Manhattan Beach. Colorado River water, purchased from the Metropolitan Water District, is being injected into a line of wells spaced 500 feet apart, and extending some 4,000 feet along the coast. A pressure ridge, or mound of fresh water, has been built above sea level that will prevent the inland advance of ocean water as long as the ridge is maintained by injection. The project to date has replenished the ground water basin with over 2,200 acre-feet of injected fresh water. The experiment is being continued to determine the economic feasibility of the project.

6. Southern California has a vital interest in the Colorado River as a present and future source of water supply. A million acres of land, more than one-half of which is now developed,

depends almost entirely upon it for irrigation water. Five million people in metropolitan areas of the Southland need Colorado River water to supplement their domestic, industrial, and municipal supply. Increased demands will be made on the river as population and industry grow.

Cities belonging to the Metropolitan Water District rely heavily on Colorado Aqueduct water to supply their needs. Santa Monica uses 97 percent of the total amount of water from the Aqueduct; Santa Ana, 89 percent; Anaheim, 71 percent; Pasadena, 65 percent; Fullerton, 57 percent. In many other parts of the Southland annexation to the district in order to secure Colorado River water is held to be the only answer -- the only available additional supply.

To meet the increasing demands for Colorado River water the Metropolitan Water District has under way a $75,000,000 program of expansion and betterment of its main aqueduct and distribution system. The area of the district is now 1,750 square miles, and the population within its boundaries is estimated at 4,342,000 people. Prospective annexations will add another 1,200 square miles to the present area.

7. The Colorado River is not the final solution to the Southland's water problem. It is acknowledged by competent authorities familiar with the situation that there is not enough water in the river for all claimants. After the Upper Basin completely utilizes its full share of water and the Mexican Treaty requirements have been met, there is not sufficient water available to supply the needs of existing and authorized projects in the Lower Basin. This deficiency may become increasingly serious in periods of prolonged drought.

If Southern California continues its phenomenal growth, it is estimated by hydrologists that it will ultimately require from some source five times as much water as the State's full rights in the Colorado River will supply.

8. In the past 50 years it is estimated that more than $1 1/4 billion has been spent in an attempt to solve the water problems of Southern California. This total includes the cost

of river control, importation of water, storage and regulation of local water supplies, flood control, and like projects.

POSSIBLE NEW SOURCES OF WATER

Where, when, and how to get more water is today Southern California's most critical problem. No one has yet come forward with a practical solution of this dilemma, but many plans have been proposed to augment present water supplies.

1. The first step in water conservation is the protection and proper management of mountain watersheds -- the "mother of streams" that furnish water to the Southland. Forest fires, unregulated logging practices and overgrazing have destroyed the tree and plant cover on many mountain areas throughout the West, with resultant loss of water, costly floods, and heavy silting of reservoirs and irrigation systems. Where mountain watersheds are within national forests, protection and proper management are safeguarded under Forest Service regulations, but with increasing demands on the forests, more funds are needed to do an adequate job.

2. One long-range water-importation plan, which has been investigated by Federal agencies, proposes to utilize the flow of the Klamath, Trinity, and other rivers in northwestern California, which is now largely wasted into the Pacific Ocean. The distance of these water sources from Southern California, some 600 miles, and the intervening mountain ranges would make this a very costly project.

3. The California State Legislature in 1951 authorized construction of a stupendous water project designed in part to bring water to Southern California from the Feather River in the Plumas National Forest east of Oroville. The Southland diversion would include 567 miles of conduits, 16 pumping plants, and 15 miles of tunnels. It would supply 1,773,000 acre-feet of water annually to areas in Southern California as far south as San Diego County. The total cost of the Feather River Project is estimated at more than $1 1/4 billion; the Southern California diversion at $795,000,000. The 1952 session of the State Legislature appropriated $800,000 for studies incident to the project.

4. Artificial production of the precipitation by "seeding" clouds with dry ice particles, powdered salt, lime, and chemicals such as silver iodide, has been tested and gives promise of success under favorable conditions. Meteorologists and scientists point out, however, that no one can make it rain when it isn't going to rain. Thus the occurrence of rain during or following seeding operations is not a measure of its success. Such an operation can only be called successful when it is proved that more rain falls than unaided Nature would have delivered. Another problem is the uncertainty of where the increased precipitation will fall -- it may occur many miles from the "target area", and even cause decreased rainfall on the area over which the experiment is conducted. In 1951 the State of California appropriated $50,000 for research into artificial rain production. Several Southern California counties have employed "rain-making" companies in recent dry years.

5. Reclaimed waste water and sewage are other possible sources of supply for industry, agriculture, and recreational purposes. Water re-use by steel mills, oil and sugar refineries, pulp and paper mills, etc., is steadily increasing. Reclaimed water is useful for irrigation of parks, golf courses, and baseball diamonds. Sewage effuents are used, subject to State laws, for the growing of field crops such as alfalfa, cotton and grain. Water reclamation costs vary from $4 to $120 per acre-foot depending on the use to be made of the water.

6. We now come to what is sometimes called "the last water hole for Southern California" -- the Pacific Ocean. The distillation of salty sea water into pure fresh water has been successfully accomplished, but to produce such water in large quantities under any present known process would probably be too expensive for general use. Practical methods for large-scale conversion of sea water into fresh water are now being extensively investigated by Federal and State Governments in cooperation with a number of universities and research agencies. Encouraging results from research and field tests are reported, but the scientists point out that many technical problems still remain to be solved.

The cold facts are that WATER is the gauge of Southern California's future economies. The development of communities, agriculture, and industry will largely be determined by the amount and quality of water available to them. A cycle of wet years, long overdue, may give temporary relief to the present acute water shortage, and the Southland may be fortunate enough to secure a larger allotment of Colorado River water. Additional water supplies are undoubtedly available from far distant sources, but it should be realized that it will take many years to build the necessary dams, aqueducts, tunnels, and pipelines -- the Colorado River Aqueduct project took 19 years to complete, of which 10 years were spent in engineering, legal and financial planning, and 9 years in the construction of the aqueduct. Meanwhile the general public in Southern California is apparently apathetic to this critical water situation -- an apathy from which it may soon be rudely awakened if drought conditions continue unabated.

No one at this time can predict the ultimate outcome of this quest for water. But of this we may be sure -- the protected national forest watersheds in the mountains of Southern California, as well as those in the Sierra Nevada, Rocky Mountains, and other western ranges, will in future years grow immeasurably in importance as a dependable source of pure water for millions of people in the Southland.

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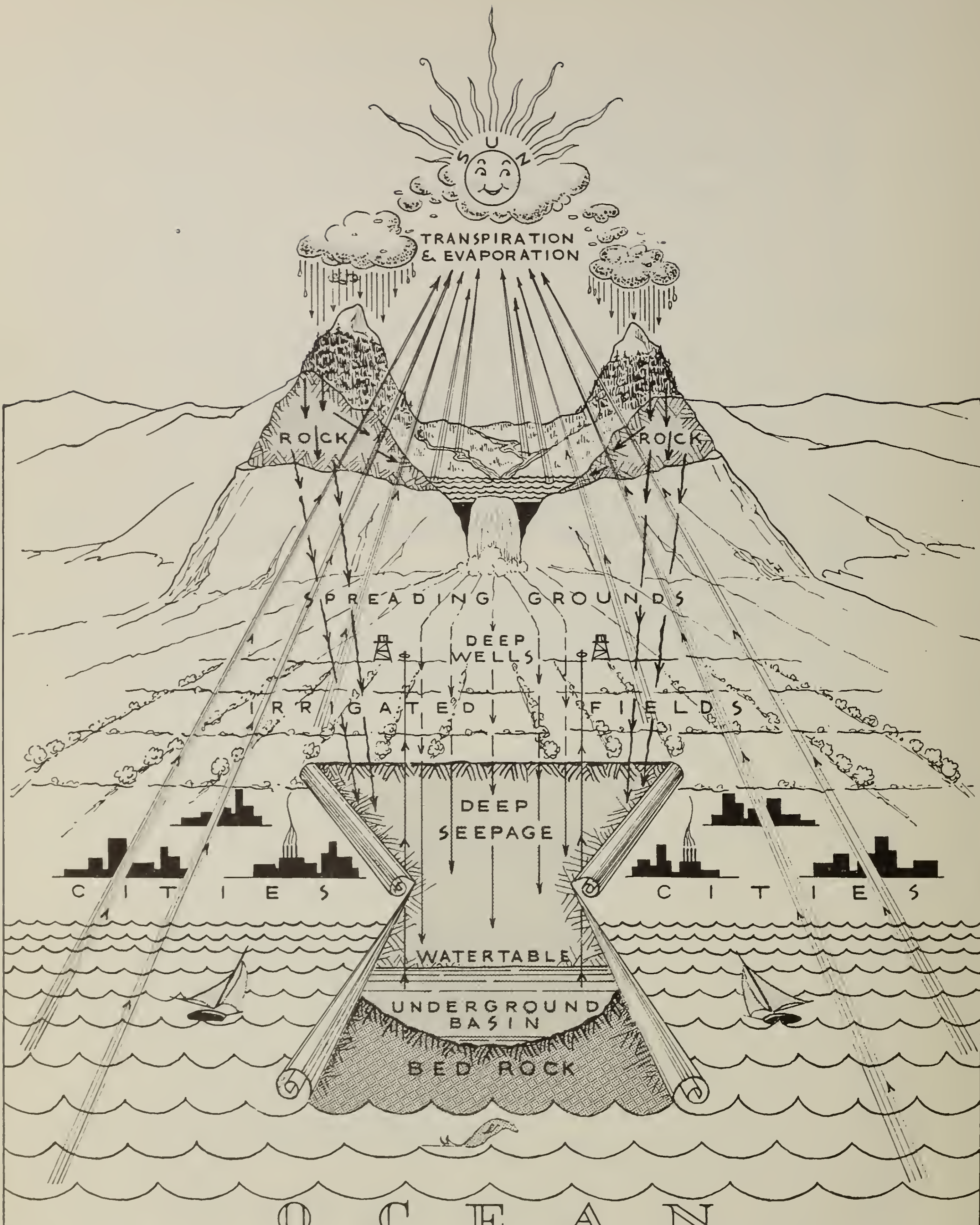

WATER CYCLE

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